REVISITING THE ARCHAEOBOTANY OF SAND CANYON PUEBLO: SAMPLING AND SOCIAL CONTEXT

by

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B.A., The University of British Columbia, 2007

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE COLLEGE OF GRADUATE STUDIES

(Interdisciplinary Studies)
THE UNIVERSITY OF BRITISH COLUMBIA
(Okanagan)

June 2016

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The undersigned certify that they have read, and recommend to the College of Graduate Studies for acceptance, a thesis entitled:

REVISITING THE ARCHAEOBOTANY OF SAND CANYON PUEBLO: SAMPLING AND SOCIAL CONTEXT

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the degree of Doctor of Philosophy.

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Abstract

This dissertation revisits the archaeological record of Sand Canyon Pueblo (site 5MT765) to explore the effects of sampling and subsampling on the recovery and interpretation of ancient plant remains. Sand Canyon Pueblo is identified as an important Pueblo III period village (A.D. 1150-1350) located in the central Mesa Verde region of southwestern Colorado. Only briefly occupied in the waning years of the A.D. 1200s, the site is similar to other large neighboring late Pueblo III villages in its catastrophic depopulation. It stands out as unique in the area, however, for its bow-shaped multi-storied site-enclosing wall and distinctive D-shaped building. Both harken back to the massive architecture and apparent ideology of the previous period that saw its most powerful expression at Pueblo Bonito in Chaco Canyon, New Mexico. The hearths, firepits, and middens of Sand Canyon Pueblo provide evidence of life lived in a time of deepening drought, violence and social upheaval. The archaeobotanical methods used to speculate on resource stress as a cause for social problems relied on one-litre sediment volumes and subsampling using a “species-area curve” approach. In experimental simulations and a re-analysis of archaeobotanical (paleoethnobotanical) samples from the site demonstrate that the richness of the plant record was underestimated. A statistically significant bias is imposed on the smallest of plant materials impacting the recovery of wild seeds and fragments, notably, ground maize. When re-evaluated through material culture and structural aspects of the site, a toolkit of pharmacologically active wild plants emerges, the significance of which is confirmed in Pueblo oral tradition that links medicinal plant use to community organization and leadership roles. Social values and the durability of social memory have been shown to be encoded in oral tradition and confirm deeply embedded mythic themes that have persisted through time, in language, and in practice. The symbolic underpinnings of Pueblo religion are present in the wild plant record, written on the architecture and imagery of Sand Canyon Pueblo, and confirm a direct, but previously unseen link with clan organization, medicinal plants and the mythic ideals of the historic and contemporary northern Pueblos.

Preface

Experimental design for simulating archaeobotanical sampling effects (chapter four) was done in consultation with Dr. Miranda Hart, Department of Biology, UBC (Okanagan campus). The content of archaeological simulations was created and managed by myself as was the analysis of data and use of species-area curves plots to describe various effects imposed by archaeobotanical screening. Statistical tests on the data and assistance in the statistical analysis was provided by Dr. Philip Molloy, private consultant.

Based on my sample selection, the Anasazi Heritage Center in Dolores, Colorado, provided archived archaeobotanical samples from the Sand Canyon Pueblo excavation for my analysis. Crow Canyon Archaeological Center staff processed the previously unexamined samples using water flotation. New taxa from these samples were identified and/or described by me. Challenging identifications were confirmed or corrected by Dr. Karen Adams of the Environmental Archaeology Program at Crow Canyon Archaeological Center, Cortez, Colorado. Specimen descriptions and identification criteria noted in Appendix C are taken directly, or adapted from, Karen Adams' and Shawn S. Murray's (2004) *Identification Criteria for Plant Remains Recovered from Archaeological Sites Data from the Central Mesa Verde Region*. Sand Canyon Pueblo site data was gleaned from two major sources: The Sand Canyon Pueblo database (2004) and the final site report (2007), edited by Kristin A. Kuckelman. The background for chapters six and seven relies heavily on the site report, and in large part, the work of Karen Adams, Kristin Kuckelman and Vandy Bowyer (2007) with additional explanations and synthesis by me. Archaeobotanical data was taken from the Multisite Research Database (on line at www.crowcanyon.org) and individual feature and special reports provided to me by Crow Canyon Archaeological Center research staff.

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Acknowledgements

I owe a great debt to Dr. Karen Adams who welcomed me to Crow Canyon Archaeological Center, the Falls Creek Rockshelters, the Hopi mesas and the world of Southwest archaeobotany. Her mentorship allowed me the opportunity to revisit Sand Canyon Pueblo and join a dedicated group of researchers studying Mesa Verde archaeology and speculating on the cultural trajectory of the northern Southwest Pueblos. I will not forget the words she offered in the last days of my time at Crow Canyon, passed on from her mentor, Dr. Vorsila Bohrer,—to promise to mentor others. I hope I have conveyed a sense of that promise in my efforts to explain and explore the importance of what we do in archaeobotany and how archaeology is richer for it. Hopefully, too, the work gives back to the descendants a meaningful vision for Sand Canyon Pueblo "artifacts." Without the generous sharing of Native Americans today and in the past, such explanations would be far more challenging to support and a loss to those who care about the people of history before "history."

I am honoured to acknowledge and thank my external examiners, Dr. Paul Minnis and Dr. Andrew Martindale for their interest in this work. To Dr. Bernard Bauer, thank you for taking on the Chair of my defense examination.

My research was funded in part by the family of Joseph-Armand Bombardier through a Social Sciences and Humanities Research Council of Canada Master's Scholarship in his name (SSHRC 766-2008-0720). Other funding includes University Graduate Fellowships from the University of British Columbia (Okanagan) and gifts in kind from others. All contributed to my continuing studies.

In the preface to his 1988 work, *Deliberate Acts: Changing Hopi Culture Through the Oraibi Split*, Peter M. Whitely quotes a Hopi man of his acquaintance as saying: "So, you *studied* us, huh? Were we *interesting?*" I answer this by saying that yes, but hardly just "interesting," it has been an education of new insights. I, too, was privileged to attend a Hopi dance. The interesting part was the power of ceremony, dignity, kindness, and respect that can be seen, and deeply felt, at a Hopi "dance." I clearly see hints of the same at Sand Canyon Pueblo. In the different building styles that suggest the welcome of others, in the special buildings that hint at a shared community, and in the art and artifacts that speak of an acknowledgement of something greater and yet inextricably human, Sand Canyon Pueblo speaks of durable values. "If ever there was a reason for bringing the humanities and science closer together, it is the need to understand the true nature of the human sensory world" writes Edward O. Wilson (2012:273), reminding us to explore something of each other's experience through the process. Often we are required to transform such phenomena into "data" to find a way into it. In the end, archaeology is a record of values and traditions of the originators. Thank you, Dr. Whiteley, for the inspiration to explore the existential for archaeological insights.

The nature of an interdisciplinary degree is to practice applied anthropology, attempting to understand and convey the unfamiliar from the perspective of the "other." My graduate committee members have consistently and doggedly done just that. My deepest appreciation and enduring regard goes to my supervisor, Dr. Roberta Robin Dods, who first taught me anthropological archaeology, but more importantly, modeled inspirational perseverance. Many thanks to Dr. Naomi McPherson who introduced me to Papua New Guinea, symbolic anthropology and the fundamental truths of reciprocity. She has read more of my papers than anyone over the years, a true testament to her open-mindedness! Thanks also to Dr. Miranda Hart, who persevered through the various twists and turns. While the inspiration for the experimental study is mine, credit for the design is hers, "digging deep" and "digging enough," as she said, is truly the answer. Beyond my committee I thank Dr. Lawrence McPherson for statistical expertise and Wayne Dods, for unlimited access to "the boss" and a dissertation library of a different kind. Former Crow Canyon interns, Ashley Dietrich and Kelly Swartz hold a very special place in my heart. Special thanks to Scott Orman, Kristin Kuckelman, and Jamie Merewether. I am truly grateful to Bernice and Ray Adamson, Marianne Thomas, Jutta Clarke, Jennifer Leason, Ian Goldie, Shannon O'Brien, Carole Graham, Ann Garibaldi, Heather Picotte, Eva-Marie Kovaks-Kowalke, Matt Husain, Tatiana Nomokonova and Trisha Rude.

I came to the study of archaeobotany/paleoethnobotany late and by way of my first anthropology course. Thanks to Dr. Sandra Peacock for this and first-rate experiences in the ancient earth ovens of Hat Creek. She introduced me to Karen, Crow Canyon, and inspiring archaeologists, Dr. Brian Kooyman and Dr. Gerry Oetalaar. My sincerest appreciation to Dr. Michael Adler and Dr. Severin Fowles for a field season in the hills above Pot Creek Pueblo with the Southern Methodist University at Taos, New Mexico.

Lastly, with much love and gratitude I thank my mother, friend and editor, for decades of being there in such wonderful ways including reading many, many drafts for me. To my daughter, Emily, who has also embarked on a similar scholarly adventure, I am so proud of you! For my dear aunt, Madge, and the others who have also passed—my father, grandmother, aunts and uncles (Tom Williamson, Kathleen Denman, Ron Jones, Betty and George Blore, and Bob Denman), most during the course of this work, you are truly missed.

> There is something stirring about finding evidences of human labour and care in the soil ... It comes to you as a sort of message, makes you feel differently about the ground you walk over every day…I wanted to see what it was like on the other side.
>
> 'Tom Outland' (Cather 1973:194).

Dedication

For Isobel and Emily with love

Chapter 1 Introduction

Background

Since its beginnings in the early 1980s, Crow Canyon Archaeological Center (CCAC), a not-for-profit research and educational institution located in Cortez, southwestern Colorado, has conducted numerous and innovative archaeological investigations of Ancestral Pueblo (Anasazi)[1] occupation in what is popularly termed, the "Four Corners." An arid region of the northern southwestern United States, the Four Corners encompasses the southern borderlands of Utah, Colorado, northernmost Arizona and New Mexico. Of particular interest is the area surrounding Cortez, which is dominated by Mesa Verde, an extensive flat-topped mountain rising above the Colorado Plateau that is home to impressive Ancestral Pueblo cliff dwellings. Beyond the shelter of Mesa Verde's overhangs numerous ancient villages occupy the smaller cliffs, canyon heads, and surrounding outcrops on the plateau below. In 1984, Crow Canyon's archaeologists and specialists assisted by students and volunteers began the first of what would become intensive studies at the Sand Canyon Pueblo site (site number 5MT765)(Varien and Kuckelman 1999). The excavation, analysis, and interpretation of Sand Canyon Pueblo has contributed to a greater understanding of the pre-contact populations that occupied the area in the late 13th century, populations whose descendants reside in Arizona and New Mexico today (Kuckelman ed. 2007; Thompson 2002:257).

In keeping with the philosophy of archaeological stewardship and conservation, excavations at Sand Canyon Pueblo were limited. Partial excavation and test trenching were used extensively (CCAC 2004; Kuckelman et al. 2007). While only five per cent of the surface area of the site was excavated, that five per cent yielded significant volumes of sediment, archaeological "dirt" and matrix, for analysis and interpretation. Of those sediments, 492 archaeobotanical samples[2] were collected for processing and 104 of those samples were analyzed (Adams et al. 2007). The interpretation of the interactions between the people and the plants they used at Sand Canyon Pueblo is based for the most part on these samples. As is typical of the majority of archaeological investigations where massive quantities of sediments are an issue, many of the samples were subject

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[1] Bahn (2001:22) defines "Anasazi" as "a Navajo word meaning 'Enemy Ancestors' first applied by A. V. Kidder in 1936 to the major prehistoric tradition of the northern part of the American Southwest." The term has, for the most part, been replaced with "Ancestral Pueblo" and is the name applied to the ancestors of contemporary Pueblo Indians.

[2] Archaeobotanical or paleoethnobotanical samples consist of plant remains and are used to reconstruct ancient environments, diets, and provide evidence of human use and impact on ancient plant communities (Bahn 2001:343).

to subsampling rather than full analysis (Adams 1977; Adams et al. 2007; Smart and Hoffman 1988). Even after the final report was published in 2007, questions remain: were enough samples evaluated and were subsampling strategies adequate to represent the richness of the plant record at Sand Canyon Pueblo?

To answer these questions I re-evaluated methods used to sample the plant remains at the site in two studies, both address overall sample volume and subsampling using species-area concepts (Mueller-Dombois and Ellenberg 1974; Adams 2004). Because of the non-repeatable nature of archeological sampling I approached the analysis in two ways: 1) through an experimental study that is repeatable; and, 2) a new analysis of previously unexamined Sand Canyon Pueblo (SCP) samples and subsamples where new evidence can be compared with the known record. My experimental results indicate that our sampling strategies impose size specific bias on plant recovery that underestimates the diversity of samples. In the case of SCP samples, wild resources were more common than previously thought. Quantifying the SCP results required an exploration of analytical transformations of "data" into cultural inferences. Like all archaeological material, the plant remains at SCP are artifacts of a particular kind, encompassing material of secular and spiritual content (Martindale 2006:162) overlapping between, and with, other archaeological evidence. To assess whether we capture the essence of this content I consider inference potential based on general categories of plant use as documented in ethnographic and ethnobotanical records. Additional sampling can be viewed not only from the point of view of representative sampling in terms of "diversity," but rather from the standpoint of potential interpretative gains at the sample level that has implications for the interpretation of the use of features, the site and beyond. While common remains are accounted for generally through these sampling and subsampling approaches, I demonstrate that size-specific bias imposed through method makes wild seeds, easily fragmented fuel woods, and processed foods such as ground maize less visible.

The archaeological evidence of Sand Canyon Pueblo provides more than a glimpse of the greater human realities of life in the Puebloan ancestral period. Through a re-analysis of the archaeology I show that the plant remains offer supporting proofs of a very particular occupation with a compelling combination of concerns. The plant remains have shed light on the grammar of the architecture and material culture at the site that are consistent with religious and social arrangements in Pueblo history. The durability of such themes through time is demonstrated by the very nature of social memory. Like imagery on rock art, material culture, in its many forms, stands as a visual dialogue (sensu Schaafsma 2013), a language that contains values and meaning that have been shown to be persistent through time and permeable under change (Crumley 1999; Lyons and Marshall 2014; Martindale 2006, 2009; Whiteley 2002). Thus, a clearer window on ancestral times is plausible through what Whiteley (2002:410) describes as a “the background of a structured set of practices and ideas” encoded in social memory, words, place and tradition. Using oral tradition, combined with ethnographic and ethnobotanical research, I demonstrate the presence of clans at Sand Canyon Pueblo and an architecture of mythic origins supported by the original archaeobotany and new plant data identified in this study.

In the laboratory: sampling strategies in archaeobotany

Devising effective sampling strategies for the recovery of plant materials is one of many challenges faced by archaeobotanists in their efforts to understand and interpret plant evidence from archaeological sites. As noted by Miksicek (1987:239), archaeobotanical sampling captures “only a small portion of the plant remains that are preserved at a site, which are in turn only a small fraction of the plants that were actually utilized by the people.” Many natural and human-induced processes impose limits on plant recovery by altering or even destroying evidence. The plant record is often comprised of fragile and fragmented botanical bits and pieces, many invisible to the naked eye that require not simply resilience through time, but the durability to withstand excavation and laboratory processing. When plant remains are overlooked or missed, it is not simply a regrettable loss. These are artifacts of content-laden categories of analysis as much as pottery or architecture. They are meaningful as evidence of human thought, decision and action, all associated with a natural environment transformed by a cultural world, a world that defined the acquisition, use, processing and discard of plants in socially prescribed ways. Over time these materials may, if resilient, become artifacts of a particular kind: situated in a continuum of time and shifting space. They provide evidence of the structure of a past ecological catchment community, ancient exploitation strategies, and an ideology of that world.

Plant remains persist into the contemporary research world by resisting archaeological transformations—how research questions, financial considerations, and methods focus our efforts and define the quantity and quality of analysis. What persists in reality is a fraction of plants used by people in that past that *survive archaeology*. Maximizing the recovery of these often minute and altered artifacts is key to understanding the “*direct* interrelationships between humans and plants” (Ford 1979:286; emphasis in original); that is, those resilient interrelationships that remain, allowing us to attempt to reanimate the record through interpretation of the culture. Sampling strategies, while aiming to capture a representative collection of botanical richness (the variety of plant taxa) can impose unintentional biases. How to achieve representative or, indeed, adequate samples is, has been, and will continue to be, a concern for archaeologists of all stripes. Plant remains, as Lee (2012:650) confirms, “are not sampled directly and randomly from a space but are contained within a space sampled." The analysis then, is not so much about the archaeological feature but rather more so about the sample volume. It is of considerable concern for all, but is particularly troubling for archaeobotanists. The nature of plant evidence is fragile; we remain conspicuously constrained by the volumes of unwanted debris, and have no reasonable way to gauge "representativeness" with confidence.

The problem

The question of sample adequacy in archaeobotany, and archaeology generally, has its roots firmly planted in attempts to classify, quantify, and compare categories of commonly fragmented archaeological remains. Accounting for the patterning of various artifact types allows for diachronic and synchronic comparisons between deposits and across sites. The goal is not to account only for numbers and characteristics but to also capture anthropological content in a way that is scientifically valid and culturally plausible. The archaeological research of the 1980s focused much attention on long-standing concerns with accounting for artifact classes and the various patterns of "diversity" of material culture in meaningful ways through the application of statistical analyses (see Leonard and Jones [1989] as an example). Pearsall (1988; 2000:242-244; emphasis added) aptly addressed one of the issues of plant quantification by raising the question that causes challenges repeatedly—*what is the meaning of abundance?* The understanding of "abundance" of a particular plant or specimen type is not simply a reflection of numbers. How do we quantify a fragment or fragments, one seed or ten, and what might this signify culturally? The nature of biology and the ambiguity associated with the presence of a particular species in one quantity or another (or its absence!), represents convoluted categories of analysis: presence (or, *why absence*?), abundance (or, is it, in fact, *preservation, scarcity* or *rarity*?), and meaning on multiple levels (environmental, taphonomic, cultural and methodological). Is it absent because it was not used, absent because it may have been used but was not preserved, absent because we did not find it, or absent because it was never recognized culturally in the first place?

In her analysis of Canadian Northern Boreal Forest precontact archaeofauna, Dods (1998:18) illustrates the quandary of artifact "presence" and its conceptual partner, "absence," and the interpretative leaps required in archaeological research. Simply put, she questions, "what does…one beaver mean in a discussion of a food economy?" to illustrate where we need to go with our data—an assessment of broader realities where the question becomes *where are all the beavers* in a food economy situated in an ecology replete with beavers? Much the same can be said of the dominant food and identity of the 13th century in the Mesa Verde region, that is, Ancestral Pueblo corn.

Borrowing from ecology, Crow Canyon Archaeological Center (CCAC) researchers use what I label here as "the species-area curve approach" (SAC)(Adams 2004) based on the "species/area relationship" concept—or rather, we curtail sampling effort through the recognition and, ultimately nonrecognition of morphological similarities to botanical family, genera or species and the identification of such data varying with sample volume. The SAC approach is a method that has been standardized through managed volume with the goal of achieving an adequately representative subset of preserved plant remains at CCAC excavated sites. We link categories of botanical identities to inferences of ancient cultural potential, potentials that we choose to focus on and select for. The aim is to achieve representative (or adequately representative) measures of botanical abundance and richness from sampling in order to propose authentic assessments of past human behaviour. But here we come up against the problem of fragments and the less-than-ideal, those materials that are challenging to identify to a firmly supported list of morphological characteristics and ones that truly reflect the practical reality of plant use—fragmentation—and the deliberate or inadvertent discard of plants and plant parts. The one beaver conundrum reflects the dilemma of the single seed or seed fragment, suggesting something truly rare, something that normally does not preserve, or something that, by virtue of under-sampling, is made less visible.

The apparent "invisibility" of plant remains in archaeological sites generally (at least without the aid of the microscope), in combination with a lack of information of traditional plant use by contemporary descendants, also imposes limits on archaeobotanical analysis. In North America, much of historical archaeological and anthropological investigations focused on the more visibly obvious artifacts and displays of ancient and historic cultures. The everyday aspects of life represented by perishable materials, associated technologies, gender and life-stage roles are rendered invisible not simply by the passage of time but by what Wobst (1978) refers to as the "tyranny" of the ethnographic record. In this regard, the record can reflect the conspicuous, perhaps misunderstanding the deeper meanings, unintentionally glossing over of the fundamentals of the human experience on the one hand, and missing the subtly and nuance on the other. The ancient American northern Southwest was, and is today, most associated with plant-oriented and "perishable" subsistence economies involving strategies for the management of domesticates—the corn, beans, squash and associated native wild plants with all their anthropological, environmental and cultural meanings. This subsistence economy, encompassing medicine, ideology, clothing and celebration is visible in contemporary farming, social structure, art and culture; resilient like none other. All hint at the original, the subtle and nuanced, even under the imposition of considerable time. Excellent preservation conditions contribute to the visibility of these plants in Southwestern archaeological sites. However, with apologies to Wobst, the manner in which we interpret ancient lifeways is more constrained by the tyranny of the "sample," or sample "volume." This "entity," in reality an artifact of research, dictates how the record is defined, in effect predetermining and manipulating interpretation in unknown and perhaps unknowable ways. The sample and its relationship to the universe it represents, encompasses a tangled taphonomy[3] in archaeological contexts. The growing dismay, keenly felt over at least the last forty years, is that our sample sizes are often small and seemingly inadequate. Yet, based on these constraints, interpretations are built (van der Veen and Fieller 1982:287). In addition, we have come to appreciate multiple transformative effects that act on remains, not only natural depositional degradation effects, but also the transformation of artifacts into "data" or "data *loss*" through our research methods.

I explore the nature of archaeobotanical sampling from the position of the interpretative value of archaeobotanical remains and how sampling effects inadvertently bias our ability to infer interrelationships between people and the plants they used in the past at the sample and feature level. Because of its shorter occupation and violent end, it is at the hearth, firepit and midden that we understand the minutia of how people lived and responded at Sand Canyon Pueblo. I show that previously perceived gaps in the ethnographic and ethnobotanical records are resolvable when considering the durability of acts of remembering encoded in oral tradition (Dods 2015; N. Lyons and Marshall 2014; P. Lyons 2003; Martindale 2006:168, 2009; Whiteley 1998, 2002, 2004) and the significance of cosmological ordering of social arrangements (Whiteley 1988:52).

Implications for analysis

While it is expected that our sampling strategies are far from perfect, we also impose other conditions on analysis that may contribute to diluted interpretations. We sample for "species." The accounting for plants in terms of species (or genus) designations (and accounting for plant parts as a type of subcategory) has some discouraging implications. There are multiple definitions assigned to the term "species," definitions that encompass categories of living (or once-living) individuals based on a variety of concepts: biological, phylogenic, and evolutionary. In this way, these categories can represent a group of individuals that reproduce fertile offspring, they can consist of similar individuals that share diagnostic characteristics, and/or reflect groups that share ancestry (MacDonald 2003:492). Accounting for species within these conceptual frameworks has different objectives than those of archaeobotanists. Our sampling strategies are founded on the concept of "species" as

[3] Taphonomy is the study of the transformation of materials into paleontological or archaeological remains, study which originally focused on processes affecting skeletons of once living organisms and now expanded to include numerous transformative effects on archaeological materials (Bahn 2001:435). Dods (1998:285) characterizes these effects as the loss of "information" that includes both natural and cultural processes from the ancient to the archaeological. Cultural filters play a role in the loss of information through the retrieval, processing and selection of remains and research goals in archaeology.

botanical entities ("taxa," as defined by the method) that at some point in the analysis signals the end of sampling. This is the foundation of "sampling to redundancy," a well-used and seemingly effective approach for capturing archaeological evidence, managing sampling effort, and accounting for some measure of representativeness. Interpretations of the ancient plant record are made within this form of taxonomic system, inferring a cultural meaning based on a definable morphology, recognizable (or recognizable well enough) to a botanical entity. The imperative, however, is the interpretation of "human *use*," the capture of complex "content." The manner of "use" often results in fragmentation. These remains, often unidentifiable to a confident assessment of genera or species, imposes a pathway, though subtle, to data loss. While we begin with species lists of *captured/recovered* flora, their use and accounting is based on inferences of how that might be meaningful as *used* flora versus anything wholly biological such as "species." The interpretation of these identities, while they may be culturally specific, must, due to lack of clear and supportable evidence to the contrary, be further reduced to broad anthropological inference much to the understandable dismay of descendant populations and without doubt to archaeobotanists and archaeologists. Herein is the problem of Ancestral Puebloan maize. By its very nature, it is fragmented through processing and rendered less visible or not visible at all, the interpretation of which walks a fine line between its apparent "absence" as an indicator of resource stress or as a proxy for abundant cultural use. If the historic and contemporary record of corn processing in the American Southwest is any indication, an abundant use of the product as milled flour and ground much like any other processed grain should, in fact, leave a signature of "absence." Ethnobotanical and historical ethnographic records of plant use provides ample evidence to caution archaeobotanists to focus their attention on fragments and indeed, the cosmological importance of plants through history in ritual contexts—the evidence of corn processing technologies providing proof that grinding occurred, and, at Sand Canyon Pueblo, occurred in abundance in very specific locales.

Through database approaches the archaeobotanical deposit is transformed into a form of pseudo "population" from which assessments of a general economy of subsistence is inferred. In this context the validity of the data are sampled, not confidently represented, particularly in a rigid statistical sense of significance testing. The "experiment" of archaeology is destroyed on excavation and the extent of taphonomic distortions can only be suggested. Without the aid of a microscope and significant analytical time and effort, we cannot be sure we have captured anything of the "used" deposit. Even before ground is broken, decisions must be made about sample volume adequate to reanimate some quantity of the target "used" plant population without any idea of the nature of site other than the obvious that often is merely the modern ground surface, our current knowledge of the surrounding environs, and the broader ancient history. Interpretation is not merely an accounting of “species” or “abundance” but, rather, negotiating a confusing set of quantities, qualities, and assumptions. Archaeobotanists grapple with these dilemmas every time decisions are made regarding how to sample. More often than not the question is one of volume: how much volume could be reasonable for a specific research question? More importantly, how do we ensure volume is meaningful? In this respect we rely on the species/genera concept for subsampling and thus, reworked again, the question mirrors Deborah Pearsall’s (1988) assessment of abundance becoming one of —*what is the meaning of species counts?*—in an analysis that is so clearly impacted by fragmentation and so primarily concerned with understanding human behaviour.

Beyond simply an analysis of sampling “adequacy,” I address the question of meaning in this research. I provide evidence of a social context for Sand Canyon Pueblo, one that proposes analogues to clans in the historic present. Archaeologist Michael Adler (1996:1-2) describes the Pueblo III era of history as reflecting a “settlement geography that closely parallels that of the historic Pueblos.” To borrow and rework his words, the archaeobotany of the Sand Canyon Pueblo site, in concert with a re-evaluation of the architecture and material remains, illuminates a *cosmological geography* that closely parallels that of historic and contemporary pueblos.

Assessing sampling strategies

Two sampling strategies for the recovery of ancient botanical remains (“richness”) used by archaeobotanists are: 1) the analysis of a standardized sample size collected in the field for the interpretation of a deposit; and, 2) a subsampling strategy also known as sampling to redundancy for processed materials for the recovery of a representative subset of particle-size-specific microscopic plant remains. These methods aim to mitigate sampling effort (time and cost) and the loss of data in the laboratory through managed volume. The aridity of the American Southwest has created excellent preservation potential for archaeological remains, conditions that are especially accommodating for the preservation of plants. This has enabled Southwestern researchers to be assured of good recovery and allows for some flexibility in terms of the number of samples analyzed (Adams 2001:50). Approaches for subsampling of processed remains have been designed to address concerns over loss of the smallest botanical specimens, those that require intensive scrutiny under the microscope and may be missed due to size (Bohrer and Adams 1977; Adams 1977, 1993a, 2004). As Bohrer and Adams wrote in 1977, “the possibility that seeds have been overlooked nags continuously” (40). This concern for seeds and for other small plant structures has become more troublesome in these budget conscious and research-constrained times.

Archaeobotanical analysis is accepted as essential to the understanding of a site, but one only has to review the archaeobotany of the past thirty years to see how the work is now being limited. A glance through the pages of editor Paul Reed's (2006) monograph, *Thirty-Five Years of Archaeological Research at Salmon Ruins, New Mexico*, illustrates the old (gold?) archaeobotanical standard for major sites. Almost 900 pages are dedicated to an array of detailed reports originally written, for the most part, in the early 1980s. Assessments of generalized plant use at this important Chacoan outlier,[4] and in-depth analysis of specific rooms and individual plant species, are detailed. Species-specific reports, such as Lentz's (2006 [1984]) "Utah Juniper Cones and Seeds from Salmon Pueblo" and Adams' (2006b [1979]) "Pines and Other Conifers from Salmon Pueblo" are just two of many finely detailed studies. Ethnobotanical inferences are explored in depth in Bohrer's (2006) chapter on "Ceremonial and Medicinal Plants from Salmon Pueblo." All express the goals of what archaeobotany strives to be; a significant body of work reflecting what it means to be human as evidenced through the preservation of our intimate and elaborate interrelationships with plants, not merely broadly defined but finely described and interpreted. The evidence recovered from 1972 to 1978 at Salmon Ruin encompasses the years that I consider ushered in a great era of expanding research in archaeobotany. This compilation speaks to a deep commitment to fund archaeobotanical analysis, a research critical to the archaeological endeavour. Like so many studies of that time, Reed's monograph upholds and reinforces archaeobotany's influence on our understanding of past cultures.

Overwhelmingly, however, it appears that contemporary archaeobotanical research is constrained by declining archaeological budgets, a lack of archaeobotanical funding (evidence of a lack of desire to fund at agency levels?) and expectations of timely reports. The full anthropological and ecological import of the recovery and analysis of such hard won evidence is less visible in reporting today. Its significance as evidence of anthropological meaning is similarly diminished. This is understandable to a degree, when funding is tight and decisions need to be made. Archaeobotanical analysis is, without doubt, time, labour intensive, and costly. Methods of sampling that curtail sampling effort attempt to mitigate these concerns of time and expense, but can play a significant role in restricting the knowable diversity or richness of archaeobotanical deposits and, consequently, the richness of archaeobotanical reports. Part of the question—how to achieve representative sampling—is an assessment of the quality of "worth" or "value" of botanical information. Always wary of diminishing returns, a true assessment of the costs and benefits of archaeobotanical research rests in how well our strategies capture the "representative" sample in all its content—botanical and cultural. Central to this concept is the potential creation of a new invisibility, that is, how funding reconfigures

[4] Chacoan outliers are ancient villages most connected by roads centered on Pueblo Bonito at Chaco Canyon in New Mexico. Chacoan outliers are noted for their large size, particular masonry, and other architectural elements. Salmon Ruins is considered a Chacoan outlier, temporally associated (five rooms showing evidence of Chacoan deposits [Durand and Durand 2008:96]) and architecturally distinctive. Sand Canyon Pueblo is a post-Chacoan village of a descendant architectural style.

what "representativeness" will mean in archaeobotanical or archaeological research in the future. The fear of diminishing returns may mitigate costs at the risk of limiting our understanding of the essential nature of human ancestral experience, an experience that is so wonderfully fragile and preserved in culturally specific and unique ways in archaeological sites. Through an analysis of what we might be missing, the research I present sheds some light on the tyranny of the archaeobotanical sample.

The research

Standard archaeobotanical sampling procedure used at Crow Canyon Archaeological Center is to collect multiple individual one-litre sediment samples from archaeological deposits for analysis of the plant remains. Sometimes, due to budgetary and time constraints, a single one-litre sample can be the only volume examined for a deposit regardless of its extent. In the laboratory, the volume is processed through immersion in water ("flotation,"[5] described in chapter two) and the resultant buoyant remains, now called "light fraction,"[6] are subjected to subsampling. One size does not fit all and requires adaptation on a site-by-site, feature-by-feature[7] basis (e.g. Adams and Gasser 1980; Bohrer and Adams 1977; Fritz 2005; Lennstrom and Hastorf 1995; Toll 1988; Wright 2010). The benefit of a standard sample size or subsample volume, however these are defined, is having the ability to know when to *stop* the process of collection, selection and analysis, knowing that the plant record has been well-represented. Researchers can then apply themselves to analyzing more samples and the interpretative task of bringing the record to life through inference (Adams, personal communication 2009). Two explicit sampling strategies are evaluated for this dissertation:

1) Standardized volume: the use of a single one-litre sample (or "flotation volume") as a strategy for capturing a representative subset of ancient botanical content (the genera/species and unique parts, or "taxonomic" richness) of a deposit; and,
2) Sampling to redundancy: the use of a species accumulation approach, an adaptation of Mueller-Dombois and Ellenberg's (1974) "species-area curve" (Adams 1993a, 2004) for light fraction as a method to capture the smallest

[5] Pearsall (2000:15) defines flotation as any water recovery technique used in archaeology for the recovery of botanical or other minute remains and is a term usually applied to all systems by which manual agitation of a soil sample in water results in the lighter botanical material floating to the surface where it is skimmed or poured off.

[6] Light fraction is the name given to light remains consisting of botanical material that floats to the surface in flotation processing. This material is examined under the microscope for identification of plant types and parts.

[7] Features are defined as any non-portable element of a site. The term includes such bounded components as hearths, interior walls or more ephemeral components such as activity areas (Bahn 2001:153).

particle-sized remains while limiting redundant subsampling. The method is abbreviated here as SAC, meaning the species-area curve "approach."

Experimental study: artificial firepits

Archaeologists acknowledge that statistical analysis of archaeological materials can be problematic. Certainly multivariate statistical tests may be inappropriate for some archaeobotanical data (Pearsall 2000:216). Samples from Sand Canyon Pueblo contain evidence of plant artifacts influenced by deposition, the passage of time, biological integrity, excavation, and later laboratory processing. The essential character of the remains is changed from evidence of ancient activity that encompasses these factors to the unknown effects of laboratory methods that in many ways are a reflection of the analysts and the decisions they make. It is impossible to re-excavate (re-process, re-sort) the same universe as first encountered because there exists no potential for producing truly comparable results. Therefore, genuine archaeobotanical samples do not meet reliability requirements needed for statistical analyses, whereas experimental data can. The experimental study attempts to mitigate these concerns and provide a valid platform for statistical evaluation of one-litre volumes and SAC approach subsampling. To quote Moore (2010:224), "when our goal is to understand cause and effect, experiments are the only source of fully convincing data." The experimental study aims to provide some convincing data that can inform what Kintigh (1984:45) writes of as a "plausible set of expectations against which the actual data can be meaningfully compared."

The SAC approach is imposed on the most problematic particle-sized remains, those less than 2 mm in size using a sampling to redundancy process. The expectation is that species capture is systematic—the collection/observations of common species are encountered rapidly and abundantly in the initial subsampling phases and taper off as subsampling captures fewer and fewer new species. An important characteristic of a species accumulation method such as the SAC approach is the assumption that the order of species recovery or, in this case, the order of identifiable botanical "observations" also indicates the point of sampling redundancy. The SAC approach assumes that archaeobotanical remains will reflect some measure of the ecological pattern of species-area relationships[8] on which these observations and all sampling to redundancy strategies are based—that all or, all but, the most rare species will be captured because of assumed random distribution of remains and the capture of common species. To test these assumptions, my experiments used simulated archaeobotanical "deposits" to compare captured species counts to known introduced

[8] Species-area relationships (described in chapter two) reflect a generally observed pattern of increased species over increasing area often described with, and as, "species-area curves." Rosenzweig (1995:8) distills the relationship simply as, "you will find more species if you sample a larger area."

species richness under various testing conditions. The data shed light on the effectiveness of the strategies through an analysis of patterning.

Revisiting Sand Canyon Pueblo: an exploratory study

Through the efforts of Dr. Karen Adams, Director of Environmental Archaeology, and Dr. Scott Ortman, former Director of Research and Education at Crow Canyon Archaeological Center (CCAC), I was given the opportunity to revisit Sand Canyon Pueblo (SCP) to answer the nagging question of potential data loss through sampling strategies using real archaeobotanical samples. The Anasazi Heritage Center in Dolores, Colorado, provided me with archived SCP flotation samples recovered by CCAC. CCAC laboratory staff provided information on specific samples and processed additional volumes excavated from the site for me. Using these resources, I explore how effectively the two sampling strategies captured the richness of SCP deposits and flotation volumes. New "species" counts provide a measure of how effective additional sampling at Sand Canyon is when compared with previously known richness measures quantified in the original analyses at the deposit/feature scale. New species, however, do not account for the value of more sampling to the original goal of the archaeobotanical report for the site: the detection and interpretation of the use of plants at Sand Canyon Pueblo. New species counts do not reflect the reality of archaeobotanical analysis where identifying remains to the species-level may be impossible, but morphological characteristics of remains may suggest taxonomic categories. Thus, botanical richness is assessed through the identification of morphology related to family, genus, or species at various levels of confidence and a measure of "richness" is quantified both in terms of numbers of new taxa and their potential interpretative value.

Interpretative frameworks

In experimental analysis, I assess botanical richness through comparison to a known introduced population and recaptured species counts. For the SCP samples, botanical richness counts are evaluated through comparison with previous analyses to determine whether additional sampling or subsampling enhances our understanding of a sample and/or deposit. The SCP datasets are evaluated for their "interpretative richness," new plants and new plant parts offering new "cultural content." The cost and benefit of capturing new taxa lies in the potential to provide inference value to support or curtail additional sampling or subsampling. This value is the true "richness" of archaeobotanical sampling. As described in the interpretation of the archaeobotanical record, Adams et al. (2007) used multiple lines of evidence to interpret the botanical richness of Sand Canyon Pueblo samples. Consistent with the report, my analysis is based on a plant identity or plant part to contribute interpretations of inferred and specific human uses of plants for food, fuel and other useful purposes (adapted from Adams et al. 2007: para.1). Four lines of evidence are used in this evaluation: context (archaeological feature type and overall context), specimen condition, diversity/richness measures, and interpretative values. All have implications for how sampling strategies can be assessed.

Context

Consistent with the Adams et al. 2007 report, samples from thermal and trash features are selected for evaluation because of their excellent potential for preservation and interpretation. These features can provide evidence for the reconstruction of subsistence and other behaviour by revealing accidents in use and in preservation that inadvertently record human interaction with plants. These contexts also offer a picture of human behavior in and through time from production to disposal that captures evidence of a “food system” with all its ecological, anthropological and cultural content (Gumerman 1997). Representing specific activities such as a final family or residence group meal found in a hearth, to general activities of a larger group or multiple residence groups in the disposal of unwanted materials, thermal features and trash are part of a continuum of human activities involving plants. The decision to mimic ancient firepits as simulated sample contexts for the experimental study is based on the preservation and botanical richness potential of thermal features generally. Middens and other trash accumulations can yield a long-term view of people’s interactions with plants, consisting of materials that were discarded and how that pattern of discard/use might change over time. The wider context of the deposition and associated material remains is considered essential to enhanced interpretation of the use of plants over both individual depositional events, trends in plant use through time, and what that might tell us about last days at SCP and trends in plant use through time.

Condition

The materials assessed are generally limited to carbonized (charred) botanical remains. Based on Minnis (1981:147), charred botanical remains are considered to be the remnants of ancient activity and thus are inferred to reflect human use in the past. Uncharred remains are often considered “modern” and therefore, incidental, although exceptions can be made for uncharred but clearly ancient plant parts. Such materials commonly preserve in the arid environment of Sand Canyon Pueblo. SCP flotation samples yielded a variety of uncharred remains that are ancient in origin. These include the exceptional preservation of corn, squash, cactus and other wild plant seeds. Charring has the benefit of higher preservation potential making the remains less attractive to animal and insect predation and more resistant to the effects of environmental conditions and flotation processing. All botanical material introduced to the experimental samples were charred to mimic reasonably authentic firepit conditions.

Diversity/richness

In ecology, the term "diversity" expresses measures that include species evenness (abundance and other species interactions) and richness (the variety of species). The term "richness" is the more appropriate term for this study as it reflects a count of the different types of taxa—the variety, and thus provides a list from which to assess sampling effort for the understanding of thermal and refuse features. The richness of plant remains recovered from additional flotation volumes and subsamples conforms to the standards outlined in the archaeobotanical analysis (Adams et al. 2007). Identification criteria rely on Adams and Murray (2004), comparative collections (both my own and the CCAC collection) and herbarium specimens from CCAC, the University of Victoria Herbarium, and the Agriculture Canada Herbarium, Kamloops, British Columbia (ACK Herbarium, Kamloops Range Research Unit). Taxonomic designations conform to Welsh et al. (1987), *A Utah Flora*, and/or the more recent United States Department of Agriculture National Resource Conservation Service, Plants website (USDA NRCS 2015). The morphological characteristics, ecological habitat, and growth habit of the identified materials support such inferences as seasonality of use and other biological potentials.

Interpretative value

The interpretative potential of identified remains encompasses the three previous lines of evidence and conforms to inferred ethnobotanical significance suggested in the original analyses (Adams 1989a, 1989b, 2007; Adams and Bowyer 1998; Adams et al. 2007; Scott and Aasen 1985). Historical accounts of plants used by Pueblo groups assume traditional links between the past and present. These offer a diverse resource of uses and meanings that have persisted through time and are critical for exploring ancient human-plant relationships (Adams 1980, 2001, 2006a [1979], 2006b [1979]; Binford 2002 [1983]:24; Bohrer 1986; Bohrer and Adams 2006a [1979], 2006b [1979]; Ford 1985; Lepofsky 2004; Minnis 2004; Peacock 1998; Rainey and Adams 2004; Yarnell 1965). Documented ethnobotanical uses are incorporated into the assessment of the interpretative value of various plant remains as another measure to test the effectiveness of sampling strategies. Typically, archaeobotanists aim to consult directly with affiliated indigenous specialists regarding their traditional uses of plants, uses that may shed light on the ancient plant record. However, more and more in contemporary archaeobotany, the absence of available, willing and knowledgeable specialists is limiting that consultation. Turner (1988:274) cautions that, at least in northwestern North America, "ethnobotanical data are derived mainly from the memories of a very few individuals and not from day-to-day living experiences of native people." This places traditional plant knowledge farther removed from contemporary analysis and even more so, from the "ancient." While traditions remain strong in Pueblo culture today, we must attend to the reality that there will be information loss. However, the ethnobotanical record documented in the recent past, provides considerable detail of the richness of traditional knowledge and action particularly where plants are integrated into a cosmological system that has deep roots in oral tradition. Revisiting the historic ethnobotanical record may be the only path to firsthand knowledge of traditional plant use today. I rely on written records to assess, at minimum, a baseline of interpretative value to provide a point of reference for consideration. In sites such as Sand Canyon Pueblo, where many affiliated by separate Pueblo peoples claim ancestry, the final interpretation of the site must be multi-vocal and open to continuing reinterpretation and negotiated meaning.

Research assumptions

Underlying assumptions for this research are that the archaeobotanical record encompasses ecological principles, botanical/biological realities, anthropological and cultural content. The record is a reflection of numerous effects that include legitimate limitations of research effort, the content of research questions, the sampling strategies used, and the transformations in the laboratory and final interpretation. The remains, both identified "species" and unidentified plant structures, have various levels of interpretative potential. The category of plant "type" holds essential value. Underlying presumptions of domesticated plants and wild plants continue to reinforce old notions of wild plants as somehow strictly adaptations to stressful conditions rather than the continuous use of such things through time. This tendency to represent wild and domesticated as different research categories is unlikely to capture the reality of the original users, that is, that "wild" was food as much as domesticated corn, beans and squash. The roots, leaves and seeds of wild plants were eaten as greens, starches and flavourings and used for medicines and ceremony. Some are historically deemed cosmological in content. Categories such as wild and domesticate therefore, encompass scales of meaning from decision-making to adaptive strategies such as shifting economies, responses to over-exploitation, and/or the introduction of new immigrants to an area with different cultural preferences. However, there are ecological and anthropological realities associated with specific plants. A poisonous plant is indeed a poisonous plant, both an ecological and an anthropological reality, in any context and at any time in history or "prehistory," a reality that is mitigated by culture. Assessing the value of genera, species, or parts, for all potential content is essential to understanding the effects of sampling.

Archaeological cultures do not necessarily reflect contemporary or historical traditional knowledge and practice even when found in association with descendant groups. However, documents describing traditional plant use are clearly important resources for inferring similarities with past use. The data was originally collected and documented from purported knowledgeable and willing plant specialists, and the records often contain impressive detail. The knowledge-holders were presumably well acquainted with the traditional use of plants by their people at the time of consultation and this knowledge was entrenched through repeated practice and encoded in language. Ethnobotanical research, regardless of its era of collection and its real or perceived bias as a European/Western/colonialist field of study, documents the connection with the past held by specialists who shared that knowledge to one extent or another with the apparent intent to educate. Embedded in the data are evidence of an ideology about the world, the cosmos, the plants, the animals, and humanity's (and "their") place in that world as they understood and held it to be true. Ingold's (1993:152) "dwelling perspective," where "the landscape [the anthropological, the cultural, ancestral, archaeological and actions associated with living in and of] is constituted as an enduring record of—and testimony to—the lives and works of past generations who have dwelt within it, and in so doing, have left there something of themselves." The act of archaeology from this perspective is "a form of dwelling" where the result can be not so much telling a story of past people, such as "weaving a tapestry to *cover up* the world, it is rather a way of guiding the attention of listeners or readers *into it*" (153).

The more recent arguments that all ethnography or ethnobotany is biased for ethnocentrism on the part of the researcher is to suggest that the essence of researcher is known, and known on a level that defines it as flawed in a way that makes its content invalid. I am not alone in a deeply held conviction that the anthropological record, ethnographic and ethnobotanical, is an important reflection of deeper meaning and represents a body of unique and authentic knowledge that provides evidence of a connection to the ancestral past. The voices of those practicing elders can be heard through the din of whatever political or racial bias is demonstrated or perceived. Combined with identified plant remains in context, this knowledge can be effectively used to measure some of the complexity of human/plant interactions through the analysis of "potentials." Dods (2007) notes that the world of oral tradition comes to us through the artifacts of that world. These artifacts were created under the influence of sets of original assumptions, ones that prompted people to make choices. The meaning of the object or the task itself resides in "recognition categories" of the original purpose, the gender and or age of the user or maker, the concepts of sacred and profane "yet unimagined or perhaps never to be imagined by us."

> The filters that comprise the taphonomic interval of past cultural distinctions compound the problem for the archaeologist since all observation "has a subjective component by virtue of the observer's taxonomic decision to recognize certain distinctions" (Allen and Hoekstra 1991:49). This is most pronounced when these filters of the past are unrecognized and thus unaccounted for as well (Dods 2007).

The importance of small remains and "their low probability of occurrence" (Ford 1988:216) have been overshadowed in the bigger synthetic cultural picture of archaeology. While there is clearly significant merit in broad assessments, we go into an excavation having expectations. This is particularly true when researching sites associated with defined archaeological eras. We expect to find evidence of domesticated plants in the plant remains associated with the archaeological culture of *Basketmaker*[9] (a pre-Pueblo adaptation). We also expect to capture a variety of domesticates in "Pueblo" sites and so we do. These are the broader assessments of human use in a "site" context. Limiting sampling has implications for these assessments. The categories of "common" and "rare" (expected and unexpected) as measured through sampling, depend on how common or rare assessments are made. While we may hope to encounter rare species in the process of sampling, we may be achieving this particular goal by reinforcing what we expect as "rare" because this category of remains is more difficult to recover and likely more vulnerable to taphonomic effects. Laboratory methods privilege the larger remains, those taxa we already suspect to be there at the expense of smaller and less visible. This study provides evidence this bias occurs. The recovery of rarely identified plant evidence particularly those remains that have no known ethnographic use, have implications for interpretation also. "Rare," like the word "abundance," can, at minimum, infer that things are not quite as we expect. This category holds cultural content much as do the smaller individual deposits, reflecting the day-to-day and often mundane reality of people's lives as preserved in the contents and contexts of family meals and other intimate activities (Atalay and Hastorf 2006). Van der Veen (2007:987) and others argue for the importance of the taphonomic content, which I apply to the individual sample for teasing out assessments of sample adequacy and cultural activity. The assessments of routine/"common" and accidental/"rare" are not simple definitions but, loaded cultural and analytical terms. Revisiting samples and deposits methodologically through analysis of sampling strategies can lead us to how and if sampling may define as "rare," the things we may have missed at the family hearth. To understand the group experience more effectively, extra effort may be required at the deposit-level; turning the tables somewhat to privilege "rare." Or, to borrow and modify Rosenzweig's (1995:8) assessment of the species-area relationship (footnote 8), you will find

[9] "Basketmaker" is an archaeological cultural sequence divided into three stages (Basketmaker I – III) based on certain diagnostic criteria defined by Kidder (1927:490). Basketmaker encompasses a postulated pre-agricultural (Basketmaker I) and later agricultural manifestation (Basketmaker II and III) in the San Juan River Basin of the American Southwest. Diagnostic criteria of Basketmaker II, a pre-pottery stage, include the use of agriculture, the atlatl and early pithouse/slab-house and pottery making. "Basketmaker" is followed by the "Pueblo" sequence (Pueblo I – V). The transition to Pueblo I is distinguished by the practice of cranial deformation, more detailed pottery, and rectangular living spaces using true masonry (Lipe 1999:65). Sand Canyon Pueblo is situated in the archaeological era of late "Pueblo III."

rare if you sample more. “Rare” may provide us with a new, more individual, yet paradoxically expansive, glimpse of the past.

The botanical remains recovered from SCP samples represent evidence of such times when stressors impacted how the Sand Canyon Pueblo people in the past “convert[ed] some part of their environment into food” (Appadurai 1981:494) and other needed things. These are things with complex meanings or, as Appadurai writes of food, “presupposes and reifies technological arrangements, relations of production and exchange, conditions of field and market, and realities of plenty and want” (1981:494). In their interpretation of the SCP archaeobotanical record, Adams et al. (2007) and Kuckelman (2007b) note that the plant remains reflect how the people responded to what certainly was, or shortly became, a hostile physical and social environment. This infers both people’s reactive and proactive responses. In the latter case, requiring knowledge depth that supported the ability to be predictive of environmental trends and mitigate accordingly. By evaluating the archaeobotanical strategies used to sample that record or, to borrow from Appadurai (with apologies), how people in the *laboratory* convert part of *the fossil environment into interpretation*, I provide data on the effectiveness of contemporary sampling practice in archaeobotany from an anthropological perspective. The qualities of systematic relationships between samples and populations are explored and the relationship between people and plants during the years of the Sand Canyon Pueblo occupation is expanded.

Dissertation outline

I explore the effects of sampling in archaeobotany in thirteen chapters. In chapter two, I outline the research problem of representative sampling and describe two strategies used at Crow Canyon− excavated volume and standardized subsampling of the smallest remains. I introduce the discipline of archaeobotany and review challenges and biases that affect archaeobotanical data. In chapter three I describe the species-area curve (SAC) approach and elaborate on its theoretical underpinnings in ecological species-area relationships. The experimental analysis of simulated samples to test the species-area curve approach is presented in chapter four. I dedicate the remaining chapters to an exploratory analysis and reanalysis of Sand Canyon Pueblo archaeobotany and archaeology. I provide background to the study in chapter five. Chapter six and seven focus on the Sand Canyon Pueblo excavation, interpretation, and sample deposition from information gleaned from the 2007 report (Kuckelman, ed.), the Sand Canyon Pueblo database (CCAC 2004), and the Multi-site research database (CCAC 2015a). Presentation of results follows in chapters eight and nine. Chapter ten summarizes the influences of sampling in both simulated samples and effects noted in authentic Sand Canyon Pueblo sampling. In chapter eleven I revisit the Sand Canyon Pueblo archaeobotanical record and identify a medical toolkit of plants found in last days' occupation of the village. In chapter twelve I use the archaeobotany, new and original, in combination with material culture and site configurations for deeper insights into the social structure of the occupation. I present evidence of clan organization at Sand Canyon Pueblo analogous to historic and contemporary northern Pueblos based on oral tradition, durability of mythic themes, and human response to trauma, made visible through a re-analysis of what is, or is seen to be, "rare" under the influence of methods. Concluding comments and recommendations for future study are offered in the chapter thirteen. The original plant record, new archaeobotanical data in combination with material culture from the site, and a re-analyis of the wild resource record have illuminated new explanations for the Sand Canyon Pueblo occupation.

Chapter 2 The problem: representative sampling in archaeobotany

Chapter overview

Archaeobotanists strive to design sampling strategies that capture a representative subset of the botanical remains preserved in archaeological deposits. Two strategies used to maximize plant recovery, manage sampling effort, and provide a measure for comparison of plant assemblages at Crow Canyon Archaeological Center are the analysis of a standardized excavated volume and subsampling of the processed remains. In this chapter I discuss these strategies and the importance of archaeological context for sampling effectiveness. I review depositional conditions, excavation, and laboratory processes routinely used in archaeobotany. I introduce the species-area curve approach (SAC) to archaeobotanical subsampling (Adams 2004), an approach that capitalizes on ecological species-area research for the calculation of species diversity as it relates to archaeobotanical samples. The conditions accepted as reasonable for calculating ecological species diversity are thought to allow for the capture of a representative sample of the smallest particle-sized plant remains present in flotation samples.

Background

One of the most cogent assertions of archaeology is Thomas' (1978:232) statement that, "archaeology's single greatest problem is coping with the magnitude of debris." This "magnitude" constrains time, financial considerations and limits what we know about past human beings and their relationships with the natural world. Mitigating the problem of debris, without inadvertently losing more data than the overburden has already inflicted, is the goal. This is particularly true of archaeobotanical analysis where remains may be significantly altered and debris continues to impose burdens on sample analysis even after processing. In addition, many plant parts do not preserve well. They do not preserve well when they have been used for some unknown purpose in the past and buried for long periods of time, many present only in unidentifiable microscopic fragments. We set a formidable task for ourselves when attempting to capture these fractions and fragments of complex biological, environmental, and anthropological interactions and transform them into a synthesis of cultural authenticity, which is indeed what we attempt to achieve. Sampling strategies are required to manage both the magnitude of *unwanted* debris in archaeobotanical samples and the time and effort required for such analysis. Like biogeographers, biologists, botanists, ecologists and other specialists, we rely on samples to suggest something approaching the reality of a larger population. Even the apparently simple species list generated from survey requires considerable effort, expertise and cost.

Inferring *ancient* human uses from a species list represents an additional layer of analysis. In this chapter I review how ancient plant evidence is recovered and how data are used to explore and understand our human past.

Dealing with debris: an introduction to archaeobotany

The study of past people-plant interrelationships, called both archaeobotany and/or paleoethnobotany, uses archaeological evidence to interpret and understand the interplay between past people and plants and the ways in which human decisions and actions influence plant ecology and express culture. Ford (1979:285) describes ancient botanical evidence as reflections of "the dynamic functioning of a prehistoric culture in relation to its environment." A sub-discipline of archaeology, archaeobotany/ paleoethnobotany are seen as interchangeable terms, although some specialists distinguish between them (Fritz 2005:773). Ford (1979:299; emphasis in original) defines archaeobotany as the "study of plant remains derived from archaeological contexts" in which the term refers to the "*recovery* and *identification* of plants by specialists regardless of their discipline;" whereas paleoethnobotany "implies their *interpretation* by particular specialists." From my perspective, the terms share common methods and goals. Similar to Miksicek (1987:211), I see the research here as archaeobotanical simply to reflect the interdisciplinary nature of archaeology and botany, to conform to Sand Canyon Pueblo (SCP) research and to reflect the tradition of archaeobotanist, Karen Adams. A detailed definition of archaeobotanical research to which I subscribe is that of van der Veen (2007:968) who conceptualizes the discipline as:

> The study of past people/plant relationships, which includes a reconstruction of diet, subsistence, agricultural strategies, the social and cultural role of food, the exploitation of wild resources, and the production of fodder. The accuracy of such reconstructions depends heavily on (a) the quality of the botanical data recovered from excavations, and (b) the quality of the analysis and interpretation of such data.

Van der Veen's definition illustrates that archaeobotany encompasses numerous aspects of complexity associated with deriving meaning from ancient plant evidence. The definition is entirely consistent with the aims of paleoethnobotanists, who also explore the intricacy of an ideational and physical world embedded in the archaeobotanical record. Fundamentally, these aspects are limited by how sampling strategies attempt to capture that complexity.

The research I present in this dissertation is concentrated on techniques of recovery of plant remains although, ultimately, those methods are useful only in our ability to apply inferences of human use. The interpretative potential or value of plant remains is constrained in specific investigative ways. Limitations are imposed by the research questions asked, the lines of evidence used to qualify and quantify the remains, and the methods imposed for recovery. Most interpretations of the plant record use a combination of mathematical measures (ratios, ubiquities and the like) to explain quantities and variations of plant presence and biotic data, to suggest what part of a particular plant might have been used and how the structure of a plant may have useful qualities for people. An important line of evidence is ethnographic data used to inform interpretation. Researchers also routinely try to consult with associated knowledgeable and, in the best cases, practicing indigenous specialists regarding research findings over the course of an investigation. This consultative aspect of archaeobotanical analysis is routine during Crow Canyon Archaeological Center (CCAC) excavations where Native Americans play active research, educational, and consultative roles. Present-day knowledge of plants however, is just that, knowledge that is held in a contemporary context possibly unassociated with traditional day-to-day practice. Caution is required when making assertions about archaeological cultures where conceptions of the ancient world may not share similar concerns. Pueblo history, however, has deep traditional ties to the past that offer intriguing continuities that resonate at Sand Canyon Pueblo. The occupation of the village clearly indicates a culture under pressure encompassing social, environmental, and economic spheres (Kuckelman 2007a, 2007b). How the Sand Canyon people responded is evidenced by the use of particular plants, uses that open the door to new explanations of the occupation.

Essential to well-supported inferences of past plant use is a reconstruction of the depositional history of the remains. These are the taphonomic, or transformative effects, of use, deposition, environmental conditions and disturbance. All have important influences on the formation of the archaeological record (Schiffer 1983, 1987). This is especially so for the plant record and all contribute to many limitations in the data (Gasser and Adams 1981; see also Hansen 2001; Hastorf 1988; Jones, G. 1991; Jones, M. 1991; Minnis 1981; Popper 1988; van der Veen 2007; Wright 2010). Taphonomic history requires an assessment of potential pathways of deposition from biological and nonbiological processes that act on plants, vulnerable to various processing and chemical effects and less likely than most archaeological artifacts to retain identifying characteristics. The deliberate transformative processes employed in the methods of *archaeology* (excavation, processing through flotation, sorting by specimen particle size) make up a series of final taphonomic stages, from the destruction of the deposit through excavation, to manipulation and analyses in the laboratory. Dods (1998:291-295) conceptualizes the process as *taphonomies*, representing gradations of increasingly impactful loss. All have what Wright (2010:42) terms “distorting effects” on our understanding of the record. A case-by-case evaluation of effects prior to interpretation of any ancient activity is required since even badly degraded deposits can still yield important information (Schiffer 1983:676-677). In my analysis of sampling effects, “loss” and “absence” can be seen through the processing and presentation of results. Individual reporting by specialty—floral, faunal, artifactual, and human remains—are noncollaborative only in the sense that the process is linear, failing to capture the linkages in cultural signatures because of the nature of reporting and the legitimate demands for timely reports. We lose inference potential and enhanced knowledge by not revisiting findings throughout the process to fine-tune what we think we see in collaboration with our colleagues. Comprehensive consultation and a kind of "group think" throughout the process maximize the combined insights of all subdisciplines, returning and reprocessing through the analytical stages for a more holistic interpretation. VanDerwarker and Perez (2010) argue for integration of both qualitative and quantitative data for zooarchaeology and paleoethnobotany. But it goes further—the enhanced understanding of each unique specialty provides a wealth of inference potential. Sampling strategies are key to the problem of "debris" and are certainly important for the management of analytical time and effort. However, sampling is fundamentally an analytical transformation. It reflects a taphonomy of data loss in the laboratory that persists into the analysis and operates on various scales. Defining those scales of loss is critical to understanding the "data" that persists.

The problem of sample size: *what is "representative?"*

"Representativeness" of sample size is, to a greater or lesser extent, subjective and difficult to determine. The term is defined as "containing typical specimens of all or many classes" (Bisset 2000:874). The idea of something being representative of another thing is defined as "a sample, specimen or typical embodiment or analogue" (874). As van der Veen and Fieller (1982:288) note of subsampling, "there is no standard way of taking a subsample, nor any guide for its size, consequently there is no way of knowing how 'representative' the sample is of the whole nor how accurately calculations made on the sample apply to the total." Full coverage is the only method that produces an accurate measure of the sample pool, the larger population. Out of necessity, how representative a sample can be conceptualized becomes a question of subjective assessments of *what is adequate,* or *reasonable* and how those terms are defined. Wright (2005:25) summarizes the problem as, "the results of analysis depend on flotation sample size, how the sample is measured and processed, and how well the plant materials within the sample withstand the rigors of flotation;" in effect, making resilience after flotation, an additional quality being measured.

The problem of the "representative sample" has proven to pose significant challenges for decades in ecological research. Cain (1938:573) addresses the problem of sampling unknown vegetative populations by asking, "what constitutes an adequate representation of an [plant] association?" In his analysis of the sampling of vegetative stands, Cain argues that "adequate representation" depends on the aspects of the community composition and its structure. He suggests that the relationship between number of species and the area in which they are found is much more complex than an accounting of individual species types because each infers a community association, a complex ecology. The number of different species or, "species richness," reflects relationships *among* species that influence numbers through multiple mechanisms. Certain species depend on the presence or absence of others, some flourish, some do not. Some species impact the environment to an extent that changes the composition of the larger community. At some level, how the community itself functions within individual ecological relationships forms the foundation for the numbers of different species present. These distinctions are important when considering how ecologists have accounted for species variety and abundance because we have relied on ecological methods to some extent to account for "cultural" species, the plant types preserved in archaeobotanical deposits.

Ecologists Cao et al. (2007:381) confirm that, "observed [ecological] species richness is derived from data for which true species detectabilities are unknown." We share similar concerns and constraints on our pathway to the illusive representative sample in archaeobotany. We are bound by similar situations that include limited resources, specified space, and samples of an unknown entity that capture an unknown proportion of available composition that, in our case, reflect an unknown proportion of the original; that is, the plants that were used. Archaeologists Lyman and Ames (2004:330) concur, "there is no sample size (ignoring that of 100%) that will allow all parameters of a diverse population to be accurately estimated statistically." Nor does one sample size, effective on some scale, work well across other scales (330). But can any sample size be statistically accurate for any parameter? Like ecologists, we are accounting for the problem of what qualifies as representative *and* a minimum of two categories of species richness:

1) The *observed* species richness recorded by analysts who count the number of species they can identify.
2) The *actual* species richness—a measure of species that are present but possibly unaccounted for.

Accounting for presence and "absence" is accounting for the bigger picture. Archaeobotanical "richness" obviously captures analyst-dependent identified species and remains that persist under imposed conditions. Species that miss the count because they are slightly out of range of the sampling frame, or due to aspects of biology, seasonality or preservation potential are lost in the process, becoming "invisible" and "not present." All "species richness" is then a reflection of how the term "representative" is understood by individual analysts and, in archaeobotany, consists of the capture of remains after the unknown taphonomic effects of *sampling*. The observation of plant remains becomes one of resilience and "identification richness" (if identification is even possible), all bound by a sampling strategy where "true species detectabilities" are unknown and unknowable (Cao et al.

2007:381). A description of typical transformative effects on archaeobotanical “species” is provided in this chapter to underscore the importance of maximizing sampling efforts to mitigate.

Factors influencing the recovery of plants and plant parts from archaeobotanical deposits

Sampling is one of numerous processes that occur towards the end of the transformative history of plants used by people in the past. Schiffer (1972) describes the archaeological record as evidence of a conceptual system formed of both cultural and noncultural processes consisting of the “life history” of “durable elements” (see also Ford 1979). This is a conceptual system—ancient, archaeological (the “excavation”) and analytical—all act on the evidence until the final archiving of material and the production of reports. Flotation processing is one transformative step but measuring, subsampling, and examination also have the potential to destroy or transform evidence. Miksicek (1987:235; emphasis added) calls these “analytical transformations *of the data base*.” How individual analysts “see,” in terms of viewpoint, and their recognition of botanical/cultural categories has impact on the database and final analysis. Identified “plants” are transformed into analytical/cultural categories such as “used” or “useful” and their associated ecofacts[10] fleshed out in interpretation. How remains are collected and recorded can impose data loss, especially when considering how to quantify and qualify fragments. Miksicek (1987) breaks down these processes into four major categories, which I have simplified and adapted for use here. An intermediate level of transformation occurs in the laboratory. The final transformation occurs in the reliance on results for interpretations of other sites (Table 2.1).

Table 2.1 Transformative categories and associated resilience factors that impact recovery and interpretation of archaeobotanical data (adapted from Miksicek 1987)

Transformative category	Contributing characteristics
Preservation	**Setting:** ecology, elevation, climate, weather, soil, and other conditions that favour or constrain preservation of artifacts.
	Resilience: artifact and associated ecofact(s)—cultural and biological—durability within the setting.

continued …

[10] Binford (1964:432) describes ecofacts as terms “applied to all culturally relevant nonartifactual data. Cultural systems are adaptive systems, and in order to understand their operation and the processes of their modification, we must be in a position to define their adaptive milieu.” Plants are both ecofact and artifact in archaeological settings providing a wealth of environmental and ecological data that can be used to propose anthropological and cultural inferences in addition to providing support for ecological realities.

Table 2.1 Transformative categories and associated resilience factors that impact the recovery and interpretation of archaeobotanical data (adapted from Miksicek 1987) continued.

Transformative category	Contributing characteristics
Cultural	**Behaviour:** processing and technological adaptations imposed in the past, cultural patterns of use and discard, either short or long-term. Impacts of "archaeological" culture—the more recent human-caused disturbance (excavation and analysis). **Resilience**: artifact and associated ecofact(s)—cultural and biological—durability in response.
Environmental	**Depositional and disturbance conditions:** ecological and geological processes, environmental changes through time. Anthropological interference, the looting of archaeological sites. **Resilience:** ecofact(s)—biological—durability under specific conditions.
Analytical	**Research focus:** the accommodation for, selection of, and processing strategies applied to archaeological artifacts in the present based on research goals, and the reliance on the interpretation by ourselves and others in future research. **Methods:** the selection, sampling strategies, processing, identification, recording and interpretation of "data." The subjectivity and intersubjectivity of the object (Dods 2007). **Resilience:** artifact and associated ecofact(s)—cultural—durability within these late stage processes.

An example of an analytical transformation is a portion of a single seedcoat I recovered in a Sand Canyon Pueblo midden sample evaluated for this study. I identified the species to *Vaccaria hispanica* (Mill.) Rauschert-type (cow soapwort) based on its very clear comparative characteristics with herbarium specimens (described in Appendix C). The specimen survived intact as a fragment of various unknown cultural and environmental processes before being captured in a laboratory screen. After presumably hundreds of years underground, an archaeological excavation, flotation, laboratory processing, analysis and photography, this specimen survived transportation from Cortez, Colorado, to Kelowna, British Columbia, an additional 400 km to the University of Victoria Herbarium and back again, only disintegrate at one last photograph session (see D.51-D.57, Appendix D). A durable element indeed! Is this fragment important evidence for the interpretation of the Sand Canyon Pueblo past? It certainly has interesting associations. An annual herb documented as native to Eurasia, Australia and southern South America (USDA NRCS 2015), *Vaccaria hispanica* is not confirmed as native to North America. It appeared to be charred. While extremely fragile, its seedcoat is clearly resilient. It was found in a flotation sample excavated in southwestern Colorado from a late 13th century archaeological site with a short occupation and a complex history. The arrival of Europeans in the area is dated much later than the temporal context of the site. The presence of a Eurasian import suggests that modern or historical disturbance was the pathway by which it entered the ancient record. The identification of seed calls into question the nature of the entire deposit and the depth of disturbance. To stretch evaluation to the boundary of its least likely interpretation, it calls into question the assessment of cow soapwort as a non-native species. Herein is an act of transformation of a specimen into "interpretation," an additional and potentially distorting process all the more problematic when the identification is assessed as "questionable."

It is evident that at each stage in the plant transformation process, data are lost. Fundamentally, however, three conditions must first exist in order to create the potential for evidence of a plant to be present and recognizable hundreds of years after its original use:

1) the continued cultural use of a plant or plant part through time increases the likelihood that it is present and recognizable in the archaeological record;
2) the resilience of a plant or plant part based on durable morphological characteristics and/or favourable preservation conditions; and, perhaps most significantly; and
3) the plant's research value to the archaeologist or funding agency.

Most negative impact may lie in the research value, which constrains or defines if the plant (if present) is recovered at all. The research value of plants is tied to the difficulty in the recovery even when reasonable constraints on analysis are clearly necessary. Sampling strategies should therefore reflect a compromise between recovery for adequate samples, however that is defined in terms of both individual sample volume and analyzed sample pool, and the budgetary and logistical problems of analysis (Miksicek 1987:235).

The most challenging of all archaeobotanical remains are small seeds and minute reproductive parts. These specimens represent wild and weedy plant species that contribute a range of interpretative potentials. Costly in terms of time and effort to recover and identify, the presence of these remains can challenge the view that domesticates such as corn, beans, and squash were the sole focus of the majority of subsistence strategies in the Ancestral Puebloan Southwest. The production of domesticates—presumably so constrained by climate, drought, labour costs, and high demand (particularly the management of corn)—has seemingly reduced or eliminated evidence of the more fluid and ecologically responsive activities associated with the traditional gathering of wild foods. Often proliferating in agricultural fields, wild and weedy plants hint at deeply rooted seasonal harvesting strategies suggestive of the wider food breadth that ancestral populations capitalized on throughout the Puebloan precontact history. The general assumption being that wild plants were supplanted culturally as change in taste preferences occurred in response to agricultural products.

That pre-agricultural foods would become less appealing and not retained their original cultural importance under the compelling onslaught of new technologies and associated ritualizations, particularly in the case of corn.

The historical ethnographic/ethnobotanical record confirms that wild plants continued to be used in abundance in the historic period. While domesticates, corn in particular, are hugely influential both as a food source and a cultural ideology n the Southwest, the rich record of specific wild species suggests that wild plants continued to play an important role only to fall out of favour in the modern period when other food options (grocery stocks) became available. The associated language and cultural narratives of native species support the contention that the old ways had and have their place and would not necessarily be relegated to emergency situations alone. In this respect, the identification of "species" as "use" categories requires critique particularly in light of subsampling for the minutest of remains.

To measure the costs and benefits of sampling for the recovery of plant material from flotation samples, I use two analytical approaches. The first accounts for species richness by quantifying the numbers of new families, genera or species, and parts encountered with additional sample volume analyzed—a "data/database" approach. This accounting scheme is used for the experimental study to suggest how effective sampling strategies recapture a known quantity and quality of introduced materials. The second scheme, an "interpretative" data/database approach, is applied strictly to the Sand Canyon Pueblo samples and accounts for the value of the individual plant types and parts for contributions of inference potential. This scheme illuminates something of the Sand Canyon people's use of plants—an approach that meets the needs of archaeobotanical analysis and the interpretation of the data on a limited scale. The ethnobotanical record of historical and indigenous plant use practices is explored to suggest the degree to which sampling techniques successfully capture potential *cultural* information. Individual "genera," "species," and "parts" have inherent value not merely as new taxa, but as new information, which, when combined with known cultural content from the final report and databases (Kuckelman, ed. 2007; CCAC 2004; 2015a), can support a more comprehensive understanding of life at Sand Canyon Pueblo. I have provided detail of documented cultural use of particular plants in the SCP study chapters to support my contention that the plant record compliments the findings of other analyses and compels new analysis of the material. Revisiting the plant and site records, too, provide evidence of clan organization and cosmological linkages with historic and contemporary Pueblo religion. Direct consultation with knowledgeable descendants is beyond the scope of this project but the data provided here are a baseline for dialogue and a starting point for future study.

Maximizing recovery of plant remains

Context

The context of any archaeological deposit both imposes limits on, and allows for, opportunities to recover ancient plants. Productive contexts consist of thermal features (primary refuse) and trash (secondary refuse). Each context type can be contained and offer good preservation conditions. Schiffer (1972:161; 1987:18, 58) defines primary refuse as cultural materials discarded where they were used and, secondary refuse, as cultural materials discarded away from their original use. Taken together these deposits reflect a continuum of human activities where plants were used or processed in one locale and their unused or unwanted remains ultimately discarded or used in another. Examples of primary refuse include such thermal features as burned spots, firepits and hearths; fire being a particularly effective pathway to preservation of plants. Middens and trash accumulations represent the discard of secondary refuse materials, the dumpsites for hearth and firepit contents amongst other features and activities. When deposits are clearly bounded (especially evident with hearths), there is an "end" to the deposit, a boundary that provides a limit for analysis also. While the accidental nature of the deposition can suggest that the parts recovered may not be the parts that were consumed or used in some particular way, there is great potential for investigation into possibilities. The characteristic patterning of primary and secondary refuse includes variations on the scope and breadth of human behaviour, the time represented, the preservation circumstances and what we already know of the typical patterning of plant remains. Underlying each of these variables is the human actions associated with the original discard and what that might mean culturally, whether the remains were deliberately or unintentionally charred, and the degree to which the deposit or the individual remains were protected either within the deposit or within a structure. The conditions and associated biases have implications for research questions.

Carbonization/charring or some level of heat alteration is a key process that increases the likelihood that plant remains will preserve through time. Charred remains are less susceptible to environmental degradation and in this condition are less attractive as food sources for animals and insects. Fire preserves and often enhances wood morphology, maximizing the potential for wood to be clearly identifiable to genus or species under the microscope. Carbonized materials typically make up the bulk of remains recovered in primary and secondary refuse contexts. These artifacts represent remnants from the preparation of meals, essentially consisting of mistakes in the accidental discard from cooking events or other activities (Adams 1977:5). They may be the traces of processing of plant parts for dyes, medicines or the construction of clothing and other useful items. Often the nature and context of the deposit can suggest behaviour correlated to group/structure size and thus infer domestic or community use. A fire in an architecturally unique structure has increased potential for inferences of gatherings or special occasions. Well-bounded features such as hearths can be productive for last-use remains, such as a final meal or other discrete cultural activity, although often they tend to be cleaned out, as is the case with some Sand Canyon Pueblo hearths. The record of use then becomes conjecture. Food preparation is presumed in these cases but reflects indirect evidence (Table 2.2).

Table 2.2 Archaeobotanical preservation and associated human use potentials by feature type

Variables	**Primary refuse (thermal: burned spots, firepits, hearths)**	**Secondary refuse (trash: middens and refuse accumulations)**
Human behaviour	• Specific activities involving plants by individuals or small groups of people.	• General activities involving plants and other materials by household or larger groups of people.
	• Specific plant use for food, fuel, light and heat.	• General plant use for food, fuel, medicine, dye, clothing and other uses.
	• Represent domestic activities such as food preparation in potentially one episode of use.	• Represent discarded and no longer useful items (tools, textiles, cordage) and accumulated trash.
Time represented	• Use over the short term such as hours to days.	• Use over time, sometimes over long periods, ranging from a few years to decades.
	• Firepit and hearth contents represent plant remains deposited during the last use of the feature (perhaps a last meal).	• May represent uneven deposition through time and encompasses multiple activities with unclear stratigraphy.
	• Burned spots may contain plants that were moved from an adjacent or nearby hearth.	
Preservation circumstances	• Typically well-preserved due to charring.	• Wider preservation reflecting both charred and uncharred materials.
	• Location within the protection of structures increases preservation potential.	• Location dependent: usually more exposed to environmental fluctuations and post-depositional disturbance (rodents, dogs, etc.) due to depositional context (indoor or outdoor).
Known patterning	• Concentrations in a small area.	• Concentrations of plant remains over a larger area with a potentially uneven depositional history.
	• Biased for foods prepared by fire, and/or for plant morphology and durability.	• Biased for foods or unwanted plant parts associated with foods or other uses not prepared by fire potentially creating an interpretative "gap."
	• May represent seasonal food preparation: indoor preparation occurring during colder months versus outdoor preparation in warmer months.	• Surface and outdoor concentrations of plants are potentially biased against preservation. Indoor deposits have a greater potential for suggesting plant use patterning.
	• Biased for trends at the time of deposition potentially providing evidence of stability or change over time.	• Biased for trends at the time of deposition that are no longer utilized. Unclear stratigraphy makes confident interpretations of change difficult.

To firmly anchor the use category "food," the analysis of human coprolites[11] is required and the pathway of ingestion fully explored (accidental or intentional ingestion). An artifact-free thermal feature can simply be the remains of a contained fire used solely for heat and light in its latest episode of use.

Secondary refuse accumulations such as middens and other trash are important repositories for plant use over time that represent multiple episodes of discard or single discrete episodes containing debris from the cleaning of hearths, firepits and floors, and the discard of old or unwanted products and materials. Often spread over space, it can be challenging, if not impossible, to intentionally sample independent episodes of discard. Trash tends to attract animals and insects, and degradation occurs naturally during the occupation as deposits accumulate. Because of this uneven depositional history, trash accumulations are often difficult to interpret temporally and challenging to firmly associate with other features excepting the obvious: closely situated rooms or structures. However, trash can contain evidence of plant use and discard by groups of people over time providing evidence of a general economy that reflects, among other activities, culturally significant subsistence strategies.

Both primary and secondary refuse contexts are biased for plants that have been subject to some degree of heat alteration and they are also "biased towards wood fuel and food-processing by-products" (Vanderwarker and Peres 2010:4). The true nature of the remains is a reflection of human activity that involves both deliberate and unintentional acts. The class of remains (and the part recovered) dictates the degree to which researchers can infer cultural actions. The plant may have inadvertently entered the record because it was brought in with another species that was used. Charred seeds may be a result of processing a plant for the use of its leaves or roots, the seed itself may have been meaningless in the cultural context. Vanderwarker and Peres (2010:3) note that, while clearly advantageous, charring "serves as a filter that often excludes plant foods that are eaten raw and have fragile structures," thus foods such as greens, roots and tubers, which would be consumed or stored, degrade rapidly leaving little or no trace and are rarely accounted for. While relying on thermal and trash accumulations for a representative sample of general plant use is biased in this respect (Toll 1988; Pearsall 2000:66), both refuse types are also known for preserving non-charred material under certain circumstances making up for some of the shortcomings. This is particularly

[11] The study of coprolites—the analysis of feces, both human and other animal—provides direct evidence of plants consumed. Coprolites contain undigested remains of meals providing evidence of diet that includes ecofacts such as the composition of past environments, the ingestion of stored food products and evidence of the season and place where food was collected (Aasen 1984:3). While coprolite evidence is direct evidence of ingestion, the remains cannot be assumed to represent "diet," however. Coprolites also contain the accidental ingestion of plant material such as pollens or plant parts for medicine.

true of deposits in arid environments such as the northern Southwest where the evidence of uncharred ancient wild seeds and domesticates is not unexpected. Representative samples then, reflect the reality of preservation potential. The perfect testing situation, the Southwest has all the conditions conducive to evaluating archaeobotanical approaches. The preservation potential, the breadth and depth of ethnographic, ethnobotanical, and archaeological artifacts, cultural continuity through time, deeply traditional knowledge and practice and a history of brilliant archaeological research all combine to allow for enhanced understanding of methods.

To summarize, plant remains are biased for preservation conditions, perhaps more so than most other classes of artifacts. Vulnerable to site formation processes such as soil type, depth of deposit, and environmental conditions, plants have a better chance of survival in the context of thermal features located inside buildings and protected from the elements. Any deposit is affected, but those located outdoors are especially vulnerable. Plant structures that do not survive well in protected locations such as a bounded hearth, preserve particularly poorly in trash accumulations even when charred. The biological properties of the plant itself, its density, surface type, characteristics and size, influence whether certain species or parts preserve (Popper and Hastorf 1988; Wright 2003). While thermally altered deposits and trash features have their problems, their general characteristics suggest potential best-case scenarios for understanding the plant record in archaeological contexts (Pearsall 2000:66). The archaeobotanical sample, the sampling frame or, the "unit of analysis," as M. Jones (1991:64) defines it, "stand[s] a relatively good chance of representing a single behavioural (or at least depositional) episode," as long as it is constrained by boundaries such as is typical of a hearth or a well-defined midden. In this respect, these features can suggest a picture of behaviour: a universe of potential interpretation that perhaps can lend itself to general statements about cultural use (and sampling volume). The nagging question of overlooked plant parts posed by Bohrer and Adams in 1977 is reflected in the concern for potential distortion imposed by methods of recovery.

The sample

Knowing that the sample "is always an imperfect reflection of the population" (Hayek and Buzas 2010:361), the question becomes, what effect does the sample have in an archaeobotanical context? The counts of individual species (or "taxa") represent fragments of an archaeological universe with the possibility of counts having more in common with archaeological methods than with the ancient depositional sequence. Each recovered species, too, has its own unique biological characteristics that contribute to the preservation of abundance or lack thereof. The sample reflects a population of flora that was fortuitously preserved and sampled under the confines of research budgets and directions, the data retaining characteristics of a complex ecology further constrained by a recognition or nonrecognition of cultural places and spaces. The strategies and methods used to collect the sample are, by necessity, decided upon prior to excavation. These reflect decisions made under survey, laboratory and staffing conditions. While it is true that "we construct past lifeways from biotic data" (Anderson 2011:2), it is a much more complex pursuit than the words imply. It is within this biotic frame that we hope to interpret humanly manipulated botanical data, with all its anthropological, biological and ecological content, and to transform it into a narrative of culture. The richness of plant families, genus, species and so on, is meaningful in a way that includes botanical and anthropological functionality. Both come into play when people make decisions about plants they prefer, plants which are useful, edible or seen as healing or medicinal or, more ominously, constitute only last resort emergency rations. This does not even begin to address plants as sacred or symbolic. In addition to providing for immediate need, the assessment of plants as "useful," also defines the schedules of human activity in the management of people for the collection and storing of particular plant parts for future use. This reality can move the analysis beyond the site habitat to a wider catchment for additional resources. It can extend to the economics of trade, both local and nonlocal. In this respect, individual species are critically important. Assessments can be made to capitalize on biological characteristics that have useful qualities for people and what this might mean for collection and/or technological strategies. The identification of archaeobotanical morphology is a complicated and constrained process, long before any assessment of culture is attempted.

Quantifying a "representative" sample is, in this respect, an inaccurate characterization. Consideration needs to be given to what can be deemed "representative." This may change with each sample, deposit, and site, and with increased knowledge of what the deposit might represent in antiquity. So it is with each new excavation. Additionally, those fragments of plants that don't inspire confident identification are often by necessity disregarded. Fragments may themselves hold unique characteristics being the end products of human action or other taphonomic processes. "Used" plants presume fragmentation and the difficulty in quantifying and qualifying fragments results in data that are lost through the "database" process and how we record what we see. Archaeobotanists acknowledge and grapple with these complications with each site and each report. If the sample is not representative of some greater entity, then what are we measuring and how do we interpret it? What do ubiquities mean if sampling effects are dramatic? Because we borrow from ecological survey approaches, to fully appreciate how artifacts become "data," we need to assess how ecological diversity is understood and how it is measured.

Quantifying "diversity"[12] in archaeobotany: the starting point

A typical survey of biotic interest to an ecologist may be to quantify the organisms present in a defined place/space. The information is collected at a particular time on a particular day during a particular period of the annual cycle where the researcher records observations of their target population(s)—perhaps one or more plant species—within a prescribed area or sampling/accounting frame. The researcher has chosen virtually all aspects of the study except the data they hope to collect: the number (or, later, calculated density/abundance measure) of the species or habitat of interest. This number is the basis for analysis and it is dependent on the researcher's decisions prior to going into the field. If all biases are described or in some way accounted for, the researcher can confidently say that, on this day-month-year, *x*-number of species were observed in the sampling frame. The presence of particular species and the abundance and distribution of those species suggest particular truths or biological facts about the habitat and surrounding natural environment. The researcher can infer potential interactions with the greater community on the basis of such data. Often, however, the information acquired from one sampling frame may be different when increasing the size of area sampled, because the scale of the study universe has now changed, as has the patterning of species (transformed into the patterning of "data"). As accounting of species increases in spatial scale, all factors associated with the study also increase in magnitude. Understanding natural populations is a multi-faceted, complicated and costly endeavour. In order to interpret the richness or diversity of plants found in archaeological sites, an understanding of plant interactions at multiple scales must also be considered. Similar to ecologists, archaeobotanists have found that there are limited options for mitigating costs. Sampling strategies are designed not only to capture data, but also to manage sampling effort/cost, with discouraging implications. The process begins with a series of decisions that starts at the selection of a plant by the original users. Out of necessity, the research question becomes less about original use and more about how much is enough in terms of effort to recapture some evidence of those original decisions. The first order of analyses includes a survey of the available diversity on the landscape surrounding any archaeological site. This serves several purposes. It provides a baseline for comparison with ancient diversity indicators, the richness of certain plant material vs. other plant material, and allows for some understanding of measures of presence, absence and abundance of recovered plant remains and what that might mean (see Wollenstonecroft's [2000] Resource Availability Model for an excellent example of a survey for

[12] VanDerwarker (2010:67-68) summarizes the measure of species diversity as reflecting two concepts: those of richness (variety) paired with evenness—the "uniformity of the distribution"—within the assemblage. The term "diversity" used here does not represent both concepts; rather it is used simply as a measure of species (or taxonomic) variety (see Peet 1974 for an in-depth discussion of ecological "species diversity").

economically significant site-specific plants and their traditional uses). Much like an ecological survey, this enables a pre-excavation assessment of the potential plants that may be preserved in archaeological deposits and assists in focusing research questions. Depending on the timing within the annual cycle (the periodicity or seasonality), some species may not even be discernable (Hayek and Buzas 2010:3). Species that dominate in the spring may appear to be invisible if the study is attempted in the fall. The timing and interval of the various seasons or, if indeed, seasonality exists at a particular location, has implications for expected recovery of material and the assessments of cultural resource acquisition that inevitably follow. Wollstonecroft (2000) goes a further step by providing a cultural survey (the Plant-Use Model) to suggest the cultural potential that is site-, context-, group- and taxon-specific, another fine example of pre-excavation assessment that can be used to support research goals.

Density measures and distribution patterning of individual species or plant cover in contemporary settings suggest certain biological (and cultural) facts. Is this an environment that has been impacted by climate, weather pattern changes, human interference or animal grazing? How might the composition of the biotic community be impacted if such effects occurred in the past? Using such approaches as Wollstonecroft's (2000) models, allows for a more finely tuned response to questions of "adequacy" or "representativeness," illuminating contemporary or historic ecological and cultural realities such as prehistoric land-use, traditional subsistence strategies and seasonal food collection potential. The analysis allows us to postulate trade or outside catchment resource acquisition. Formalizing such models can focus research questions in a way that clarifies expectations and allows for appropriate and productive attempts that can be adapted to specific sites prior to the first sample being excavated. However, while they aim to provide for the capture of representative richness measures, samples are configured in terms of volume. Volumes of sediment are excavated in the field, processed (by flotation) and finally subsampled in defined volume quantities, all relying on the apparent success of previously utilized sampling strategies. These are described further here.

Sampling strategies for flotation and light fraction

Sample size for flotation volumes

In the bigger picture of archaeology, Fish and Kowalewski (1990) argue the merits of complete survey (the "100 per cent survey") of large geographic areas in order to understand not simply an archaeological site, but also the ancient settlement patterns and community structure that the site is embedded within. Similarly, when sampling features or anything else in archaeology, knowledge of the sample universe is a factor in justifying how a sample can be deemed representative and meaningful. Obviously, redundant effort is to be avoided. The "representative" question nags at the feature-sampling and sediment-sampling level for every site (Adams, K. 1986:1). The value of full coverage surveys, like the complete scanning of flotation sediments, resides in the benefits: the information gained from the extra effort must justify the costs. One-litre of sediment under the microscope can look like a 100-km^2 survey area in terms of time and effort; it is merely a matter of scale. Both are impacted by the same problems: the biases in preservation, the chance selection of productive or nonproductive samples, the time and financial considerations associated. All contribute to the prejudicing of the data depending on the focus of, or limitations placed on, investigations. Archaeobotanists have responded to these concerns by standardizing volumes of sediment, typically excavating samples in one-litre individual flotation volumes (collecting many where amounts vary between sites) as a way of achieving, at minimum, a consistent measure for the comparison of data. Costs may constrain the number of individual volumes analyzed but limits must be established as, in most cases, the debris associated with flotation samples is unmanageable in terms of analytical time.

The one-litre sample volume is the single unit employed routinely at Crow Canyon Archaeological Center (CCAC). It can be a standard measure of comparison between features and serve as the basis for ratio and density measures. In the case of ephemeral features, such as a small one-time fire, one-litre can be difficult or impossible to collect (Pearsall 2000:75) and smaller samples are not disqualified on the basis of insufficient volume as the amount may represent the complete deposit. Dunk (2006:30) records that at Shields Pueblo (Site number 5MT3807, A.D. 500-1280, located northeast of Sand Canyon Pueblo [CCAC 2015b]), one-litre was collected “wherever possible,” but the volume varied depending on context. As a measure of comparison, the one-litre volume has its flaws. Sample volume is impacted by various aspects of site environment and geography. This includes how much overburden has accumulated, the depth and breadth of modern plant cover, the soil type, quantity of clay, rock and other debris. This is particularly problematic when sampling first excavated samples that typically contain more modern debris and sediments than within-deposit samples where the bulk of the content is presumably ancient.

CCAC’s use of one-litre volumes is based on experimentation at multiple sites in and around Sand Canyon and around the Four Corners area. As a measure of analysis, a standardized excavated volume provides a standard for comparison between samples, deposits and site data. A deposit may be interpreted based on a single one-litre sample in some cases. How much is analyzed is subject to research goals and the degree of sampling effort budgeted. Whether large or small in volume, overall sample size is affected by decisions regarding how many samples are examined and, importantly, the size grade of material examined within the volume. The choices made regarding the size of specimens to be included in the analysis impact the number of samples it is possible to assess. While some plant remains may be visible enough to collect by hand, the majority of plant data comes from the microscopic remains accessed through flotation and the microscopic analysis of light fraction. Some bulk sampling examples from archaeological investigations around the world suggest that there is a wide range of standardized volumes (Table 2.3).

Table 2.3 A selection of sampling strategies by volume published in 2000 or later

Research goals in brief (alphabetically by author)	**Sampling strategy**
Food activities as nutritive acts embodying group and sociality at Catalhöyük, a 9,000-year-old Neolithic Anatolian site, Turkey (Atalay and Hastorf 2006).	1-60 litres (averaging 30L) for each identified unit.
Multiple recovery strategies were employed to capture evidence of plant use at an early settlement (the Three Dog Site) in the central Bahamas to explore subsistence activities, paleoenvironment and economic plant-use patterning (Berman & Pearsall 2000).	20-22 litres from each cultural level of each excavation unit (102 - 1x1 m square units).
Human transportation and manipulation of wild plants in Late Bronze Age lakeshore settlements, French Alps (Bouby and Billaud 2005).	1-2.5 litres per archaeological layer.
An exploration of Kintampo culture subsistence economy and cultivation of domesticated pearl millet (*Pennisetum glaucum*) at the Birimi site in fourth millennium BP, northern Ghana, West Africa (D'Andrea and Casey 2002).	.5-60.5 litres per context for a total of 394 litres of soil.
The earliest agriculture and domestication of millet-grasses and pulses at 12 sites in Neolithic, Southern India, third millennium B.C. (Fuller et al. 2004).	A minimum of 20 litres to multiple 20-litre samples from each stratigraphic unit.
Investigating social, economic and mobility patterns as reflected in evidence of non-local plants remains from the Scowlitz site, a 3000-year-old Coast Salish site, Northwest Coast, British Columbia through the use of a model of ancient plant use (Lepofsky and Lyons 2003).	1 and 2 litres from hearths, floors, a pit, burn features, surfaces and a cooking feature.
Agricultural development and evolution of social and political complexity of the 3600-year-old archaeological record of the Jama River Valley, coastal Equador (Pearsall 2004).	20 litre samples from each natural or arbitrary excavation level and one separate sample from each feature. Increased sample size in later years of the project.
Thirteenth Century diet and land use at the capital of the Mongolian Empire, Karakorum, Mongolia (Rösch et al. 2005).	10-20 litre samples from charred layers, mixed cultural layers, cesspits and closed find assemblages.
Exploring subsistence change from egalitarian sharing of food to long-term storage and hoarding at Mandalo tell, a Late Neolithic to Early Bronze Age hamlet site, Greece (Valamoti and Jones 2003).	40-50 litre samples from large features. Smaller features (hearths and post-holes) sampled in their entirety.
Late Upper Paleolithic diet (22,500-23,500 cal. B.P.) at Ohalo II (Israel), a submerged Sea of Galilee lake site where plant evidence patterning from the recovery of approximately 60,000 identified seeds and plant remains suggests activity areas and hints at sexual division of labor (Weiss et al. 2008).	Basic sampling unit typically 10 litres. Occasionally the entire locus (Weiss and Kislev 2008:165).

A standard individual volume size for a flotation sample collected in the northern American Southwest is typically one litre (Adams 1977:13, 2004; Bohrer and Adams 1977; Dunk 2006). Fritz

(2005) records the commonly one to three litres for Ancestral Pueblo sites although many strategies are employed. Fritz (2005:786-787) makes the following sampling observations: for the Eastern Woodlands and the American Bottom (west-central Illinois), a 10-litre sample is considered standard and collected from each level of excavation unit, or 100 per cent of feature fill where pits are less common. In southern Arizona, all feature fill is considered the sampling unit because density of charred remains is low. The nature of the geography, ecology and research goals define volume excavated and analyzed.

Flotation: transformative recovery

Flotation is a water processing technique used to capture small and microscopic plant remains such as wood charcoal, seeds, reproductive structures and other organics embedded in archaeological sediments. First applied in the field in North America by Struever (1968), some form of laboratory flotation has been used since the 1950s (Pearsall 2000:19-20). Flotation revolutionized archaeobotany and with it came an entirely new magnitude of debris and a much more pressing sampling problem. With access to so much new and microscopic material, decisions about what not to analyze became an overriding concern. It is rare that the plant evidence recovered through the flotation process does not continue to impose considerable analytical problems in terms of volume. The process of flotation aims to remove extraneous sediment either manually or by machine although often a range of minute-sized sediment and debris is retained. The general manual process is described below.

By mixing excavated sample volumes with water in a container, the lighter weight organic materials are released from the sediment matrix and float to the surface where they are skimmed or poured off and dried over a period of days. This dried material, now called the "light fraction," represents the lighter, buoyant plant materials that are then examined in the laboratory. The remaining material that does not float consists of stones and modern matrix and heavier artifacts such as stone flakes and bone. This material is the "heavy fraction" portion of the sample and all samples excavated in the field destined to be subject to flotation, are called "flotation samples." An abridged description of the CCAC flotation technique follows as adapted from Ortman et al. (2005:11-17).

> Excavated sediment samples are slowly mixed with water and gently stirred in a one-gallon bucket. Once the bucket fills to ¾ full, the contents are left to sit allowing the lighter material to float to the surface. The bucket contents are then carefully strained through a fine nylon mesh (0.355 mm wedding veil material), capturing the organic material. The bucket is then re-filled and the process repeated four times and the buoyant material collected. The mesh and organic material is hung to dry. When dried, the "light fraction" is screened and examined under the microscope. The remaining material (heavy fraction) is collected, dried on newspaper, is examined or curated should further analysis be desired.

It is important to note that the sampling strategies documented in Table 2.3 reflect original volumes of sediments collected in the field. These samples will be processed to separate the organics from unwanted sediments and matrix by some form of flotation or other separation process. The volume of ancient plant material recovered through this process is unknown for these examples. A decision as to the "depth" of analysis—how fine the analytical process goes in terms of specimen size—varies.

Managing the light fraction: the method

The subsampling strategy formalized by Adams (1993a, 2004) to deal with the light fraction content of flotation samples is a "species-area curve approach" (abbreviated here as SAC). It is a sampling to redundancy (STR) strategy for the management of light fraction volumes first standardized and applied to flotation samples at the Duckfoot Site near Cortez (Adams 1993a) based on initial research in subsampling at Salmon Ruins, New Mexico (Bohrer and Adams 1977). The SAC approach limits the volume of light fraction analyzed for the smallest particle sizes of remains. As an institution with a focus on research and education, CCAC has a long association with innovative researchers and focuses considerable efforts on refining and improving techniques in archaeology. The Duckfoot site was the first major archaeological investigation completed by CCAC in its evolution as a fully developed archaeological facility (Lightfoot and Etzkorn 1993). Stuart Struever, who refined the process of flotation for the recovery of plant remains in the field, also served as the first president of CCAC. At Duckfoot, Adams dealt with the scope of analysis through standardizing various strategies for flotation samples: sorting processed samples (the light fraction) into size grades as she did at Salmon Ruins (Adams 1993a; Bohrer and Adams 1977), examining smaller volumes in their entirety and, estimating potential recovery on unexamined portions of larger volumes. Most importantly, smaller particle sizes retained in the light fraction were dealt with through the use of a calculated light fraction volume for analysis. This standard subsample size, defined as "the volume of material that can be packed, but not piled, contiguously under a [microscopic] field-of-view for each particle size" (Bohrer and Adams 1977:40), is a convenience that allows for more efficient microscopic analysis by minimizing the need to continually refocus while scanning material. The volume effectively serves as an archaeobotanical equivalent to an ecological plot size and "minimal area" (fully explored here and in chapter three) for the recovery of sample (particle size content) richness. Using this volume, the species-area curve approach was developed, modeled after Mueller-Dombois and Ellenberg's (1974:52-53) species-area curve for the capture of ecological diversity. Adams (1993a) identified two advantages for archaeobotanical subsampling through this approach:

1) More analytical attention is focused on particle-sizes thought to be richest in taxonomic diversity (the larger particle sizes). (It is important to note that research decisions define the particle size of material to be scanned.)
2) "The samples themselves provide data helpful in deciding whether to continue or curtail sampling" (Adams 1993a:196). In other words, the more plant material (diversity or richness) recovered, the more analysis is imposed. The underlying assumption is that ancient taxa are randomly distributed within each sample and have an equal chance of recovery (196).

Based on the assumptions associated with species-area relationships in ecology (Mueller-Dombois and Ellenberg 1974:52-53), the SAC approach aims to achieve a representative sample without redundant effort based on the presumed homogeneity of a sample as representing a discrete episode of use and the presumption that the capture of taxa is systematic and reasonably predictable. The method of light fraction processing and subsampling is described in the remainder of this paragraph as adapted from Adams (2004) with added observations and comments from me: After flotation and drying, the light fraction is measured for total volume and put through graduated geologic screens (W.S. Tyler U.S.A. standard test sieves) of particle sizes: 4.75, 2.8, 1.4, .71, and .25 mm. This process subdivides the samples into "portion," "particle," "screen" or "sieve" sizes (the terms are interchangeable). All portions are subject to some degree of subsampling. The largest screen size, 4.75 mm, is completely analyzed for non-wood specimens and subsampled for wood (paras.24-25). Twenty specimens of charred wood (based on difference in size and placement in the screen) are selected for identification. The 2.8 mm portion is also completely analyzed for non-wood specimens and, if 20 specimens of wood are not available in the larger screen, then subsampling for charred wood continues in this portion. Morphologically distinctive specimens may be added if more than 20 are available in an effort to maximize the greatest variety of wood taxa. The smallest screen sizes (the 1.4, .71 and .25 mm screens only) are subject to subsampling based on the SAC approach (Adams 1993a, 2004). The 1.4 mm and .71 mm screens are examined under the microscope in subsampled amounts of .9 ml each. The .25 mm screen portion is subsampled in .3 ml volumes, in the same manner. These standardized volumes are based on the quantity of portions of the light fraction that can be easily managed under a microscopic field-of-view and adjusted for particle size (Bohrer and Adams 1977:40). For each portion/particle size, three consecutive subsamples of the standard volume (.9 or .3 ml) are examined until no new botanical families/genera/species or unique parts are identified. Three consecutive unproductive subsamples (those subsamples containing no new taxa) indicate the stopping point of analysis. The sample is then considered completely analyzed, and the taxa identified are presumed to adequately represent the variety for the screen (Adams 1993a, 2004).

Recovering a representative measure of botanical richness and still being able to stop examining light fraction is key to the SAC approach. As with flotation sampling by feature, subsampling by light fraction is designed to suggest when to *stop* subsampling, ensuring that sampling effort does not become redundant (Adams 1993a; Bohrer and Adams 1977:40; Popper and Hastorf 1988:8). The approach capitalizes on a taxon accumulation strategy that mimics ecological species-area patterning.

The concept of "species richness" has parameters in both archaeology and ecology. Mulugeta et al. (2001:217) describe ecological species richness as "the total number of species in a discrete patch of habitat, which varies with the sample area (i.e., species-area relationship)." The same concept is applied to the number of identified plant taxa in flotation samples. The sample functions as a proportion of a "discrete patch" where "species" richness (in effect, botanical content) can be quantified. The species-area relationship can be modeled using this data, graphically presented, where individual identified species are plotted against the area sampled (in our case, "volume") and a line fitted to the points creating "the curve." An ecological species-area curve provides not only a measure of sample size, but also suggests a level of complexity within ecology's discrete patch (217). For archaeobotany, that "discrete patch" is the archaeological deposit (or when the full deposit is not excavated, a portion) or, simply, a single flotation sample. As in ecology, the "curve" approach is intended to curtail redundant scanning of microscopic material through recording species accumulation until no new species are encountered (also known as the "sampling to redundancy"). The benefits include the purported capture of the total ("representative") range of species variety and aim to accomplish three objectives important in archaeology generally, and archaeobotany, specifically, which are:

1) Optimizing (or representing to some degree) the recovery of taxa of interest (botanical or other types);
2) through systematically documenting observations of new taxa, the SAC approach defines the size of the sample required to accomplish the same; and,
3) sample size constrains sampling effort and analysis time because a point of redundancy is presumed (as per Lyman and Ames 2007:1986).

The strategy is a practical solution to the problem of the cost in time, effort, and financial considerations vs. the benefit of recovery of new taxa, accomplished by plotting a measure of sampling effort in some samples in order to calculate sampling for others (Lyman and Ames 2007:1986). The thought is that similar to ecological species-area relationships, those samples rich in new species will invariably require more effort, those with little will require less. The species-area curve approach and the theoretical underpinnings of ecological species-area relationships are explored in depth in chapter three.

Chapter summary

The interpretation of the plant record is constrained by boundaries. The time commitment required for processing, analysis, and the legitimate budgetary considerations of archaeological investigations impact the collection, selection, and analysis of archaeobotanical samples. The single flotation sample and the subsampling of the resultant light fraction reflect the practical mechanics behind the original construction of, and analytical *re*construction of, what van der Veen (2007:968) describes as the robust, but oftentimes overwhelming, complexities of the archaeobotanical record. Standardized flotation sample size and subsampling approaches are strategies used to rationally curtail the analysis of the magnitude of debris that represents the archaeobotanical record; the captured portion of the archaeological record. As a species accumulation technique the SAC approach aims to achieve these goals.

Chapter 3 Explaining the curve: “the sharply rising line that tapers off” and the capture of species richness in flotation samples

Chapter overview

The recovery of archaeobotanical richness from subsampling light fraction from flotation samples is modeled after species-area and minimal area concepts used in ecology for calculating and capturing the diversity of vegetative stands (Mueller-Dombois and Ellenberg 1974). The ecological species-area relationship is thought to be predictive of species diversity measures because of the patterning associated with accumulated observations of species. The archaeobotanical equivalent, “the species-area curve approach” (SAC), capitalizes on this research. The SAC method aims to limit light fraction sampling effort by subsampling the smallest particle sizes using a defined yet flexible volume that is thought to respond to the diversity of a sample. In this chapter I present a discussion of the approach and the theoretical underpinnings of species-area relationships in ecology, relationships that inform the SAC application in archaeobotany.

Background

> Regardless of the measure of effort chosen,
> fieldwork will produce an initial period of rapid accumulation of information,
> as the first biological samples are examined. As each succeeding sample is observed,
> we will find fewer and fewer …new species
> (Hayek and Buzas 2010:259)

Is the next sample worth taking [processing, analyzing, documenting, evaluating], *given the effort* (Hayek and Buzas 2010:259)*?* The species-area curve (SAC) approach was designed to deal with this question. Formalized by Adams (2004) the approach is a sample-based sampling to redundancy (STR) strategy adapted for flotation sample analysis from Mueller-Dombois and Ellenberg’s (1974) “species/area curve” and “minimal area” concepts for modeling and calculating species diversity, specifically plant diversity in ecological habitats. The SAC approach capitalizes on species-area curves, the graphical representation of the so-called “species-area relationship” (SAR): the repeatedly observed increase in species diversity over increased area in nature that seemingly reaches an identifiable plateau. The patterning or shape of species-area curves is thought to indicate the point of maximum species diversity/richness in ecological sampling situations or an adequate subset. Useful to archaeology and archaeobotany because of its apparent predictability, we have relied on this body of ecological knowledge to formulate our own “curve” approaches and manage sampling effort. Recent research suggests that more is at play in the ecological species-area debate. Rosenzweig (1999:276) notes that much of what has been traditionally seen as the "mathematical regularity" (read: universality) of ecological species-area relationships assumes similarity across spatial scales. "The puzzle of the species-area relationship is now in retreat" because predicting diversity requires consideration of the impacts on diversity by speciation and productivity, a "context" for species numbers.

The SAC approach (Adams 1993a, 2004) borrows from the concept of mathematical regularity and over a century's worth of mathematical and statistical diversity research in ecology and biogeography. The species-area relationship and plotted species-area curves have apparently indicated the diversity of a geographic area and in the process identified the point at which further sampling of a habitat is reasonably redundant (the sampling to redundancy process). The concept of redundancy of sampling effort is highly attractive for archaeology as it provides a cut-off point for further analysis, the costs of our research being high and the volume of material for analysis challengingly "large." To accomplish the goal of representative (or adequately representative) samples and avoid redundant effort, some archaeobotanists have sampled and subsampled to the point where no new species are observed using the concepts of species-area regularity and the assumptions of redundancy on which they are based. This has presumably allowed us to deal with the very real problem of excess debris and matrix characteristic of flotation samples and to limit unnecessary effort in analytical hours and the attendant costs associated with combing through massive quantities of microscopic sediments. Complete analysis of flotation samples, even when limited to individual litre volumes, is inevitably beyond the scope of most, if not all, archaeobotanical studies. The assumption of sampling to redundancy generally, and the SAC approach specifically, is that redundancy is reached through this limited sampling process because of the overwhelming evidence of species-area relationships that follow a pattern that appears to be identifiable, predictable, and meaningful.

Archaeobotanical samples contain content that is thought to be randomly distributed (Adams 1993a:196) based on the presumed effects of deposition, taphonomy, archaeological excavation and laboratory processing. Thus, there is an expectation that borrowing from species-area concepts that rely on random sampling and Normal probability distributions will be successful for our data also. Like ecological species-area relationship patterning, it is thought that the capture of botanical remains or archaeological artifacts will also be patterned in a way that allows for similar predictions and estimations. Hayek and Buzas (2010:14; emphasis added) define random sampling ("the best way to ensure an unbiased estimate…") as *the process* by which data are obtained, each sample having an identical chance of being selected (a statistical probability). It does not "describe the data in the observed sample." Furthermore, they caution that the term "random" has different meanings. "Usually observers using this term mean "random [spatial] distribution" and that they see no readily apparent pattern." There are, however, three kinds of spatial distributions: 1) random, meaning *no pattern*; 2) aggregated or clumped, meaning *discrete groups*… and 3) even, meaning that the individuals are *evenly spaced* (69). These are, "visual descriptions, not probability random distributions" because there is no such entity as a "random distribution" in statistics (69). Random sampling, however, is a *probability distribution* based on the normal bell-shaped frequency curve where the majority of plotted data falls within the curve of a plotted distribution.

The concepts that underpin the SAC approach, the language and the mechanics associated, are described in this chapter.

The language of the "species-area curve"

In order to appreciate how ecological concepts and methods have utility for the recovery and interpretation of ancient "used" plant remains ("used" being an important distinction!), an exploration of some of the more common terminology and concepts that tend to describe species-area curves is required. Furthermore, the SAC approach is built on assumptions associated with a pattern that emerges when plotting the cumulative observations of new species on a graph. The typical pattern of a line that curves to horizontal becomes almost incomprehensible when various mathematical equations and statistical analyses are used to describe them unless, of course, you are a statistician and an ecological specialist. Even then, debates continue over the meaning of these patterns.

The species-area concept is one that relies on the assumptions of probability theory, the plotting and statistical analyses of two phenomena that vary in relation to one another and in the end, yields important ecological information. The pattern of accumulation of new species and the mathematics are, in effect, the "species-area curve," or more accurately, the *shape* of the curve. The shape of the curve suggests something about species composition, the species-area relationship or, the "SAR." The curve may, however, model how sampling "accumulates" new species and what that might show about the richness or diversity of a sampled area or, indeed, a sampling strategy, depending on the data analysis. Species-area curves are seen as effective tools for modeling diversity in ecological sampling because of the strong correlation between the diversity of an area and the size of an area. Larger areas tend to have more species. Key attributes are the pattern associated with SARs, how the data are categorized in terms of diversity, and how the curves are interpreted as estimating diversity.

Patterns

As Hayek and Buzas (2010:259) report in the introduction of this chapter, when sampling in nature, common species are observed quickly in the initial sampling phases, becoming less and less common ("rare" or "rarely observed") until no new species are noted. When the data are plotted and a line fitted to the data points, one can see a curve or, "*the* curve" (a simplified version of the typical species-area curve is presented in Figure 3.1, p. 61). This graphical representation reflects the so-called SAR (or SARs), a relationship(s) that suggests something of the composition of species diversity over area in a particular habitat or habitats. Using this approach, ecologists have plotted observations of individual species and accumulated community compositions over a range of habitats to understand and theorize the effects of habitat and biology on species numbers. The quality of the relationship is modeled through mathematical formulas to suggest universals of particular diversity patterns. In order to assess diversity at various scales (individual, community, population), recognizing when redundant sampling effort is reached seemingly captures this "diversity" and, at the same time, modeling area requirements for species sustainability. Most pressing, species-area research is focused on data collection for the preservation of biodiversity, a serious concern in habitat loss, although accounting for any phenomenon that varies in response to another uses the same mathematical/statistical reasoning. The species-area curve strategy demonstrates a process by which data can be plotted to illuminate patterning. It is assumed that sampling after this point will yield only the species already accounted for. Based on our limited sampling strategies using sampling to redundancy methods such as the SAC approach, our patterns appear similar: species accumulate rapidly in the initial sampling phases and taper off as observations of new species become rare occurrences. The process of reaching that point has been seen as the capture of initially common species followed to some degree by rare species where rare is often viewed as "outlier."

The "curve" associated with many of these studies, as well as those associated with the SAC approach, is an *accumulation* curve not technically a species-area curve (a subtle but important distinction described in more detail in this chapter). Accumulation curves tend to be patterned with the same regularity as species-area curves. They reflect the plotting of new species as they accumulate through the sampling process, thought to estimate diversity or richness of samples because they too, graphically identify when additional sampling appears to be redundant. If new habitats are unwittingly sampled in the process however, new ecological (or archaeological) communities are introduced with all their associated common and rare species. The "island" or, concept of an "island," is helpful in this respect. Islands are insular; they impose limits on the accounting of new species. They have very effective boundaries (oceans, lakes, rivers) to immigration and overlap of communities. Although islands may also contain different habitats with varying species compositions, the idea of sampling a bounded space is key to the effectiveness of curves for useful and meaningful data. In the case of islands, they provide the most clearly constrained populations and the best-case 100 per cent survey situation possible outside of the laboratory. The significance of islands was understood early in species-area research (Arrhenius 1921).

Some archaeobotanical deposits represent “islands” of debris. Many have boundaries such as hearths or firepits, but all typically require sampling rather than full analysis due to the volume of material, both ancient and modern that naturally accumulate over time. If species-area curves can provide a mechanism for identifying the diversity of a well-bounded ecological space, then perhaps they also serve the purpose of restricting redundant sampling effort in other well-bounded spaces. It is important to appreciate that it is possible to lose track of the purpose and effect of what the SAC approach is—a sampling approach based on a pattern of accumulation, one that assumes that “redundancy” exists and is predictable and seemingly provides an adequately representative subset of a population. Contributing to the confusion begins with the concept of “diversity” and how it is defined and applied, but it does not end there.

Diversity

The term “diversity” is used to reflect different values that in many instances are assumed but not fully described. Often we use the term to simply talk about variety. It may account for relationships between species that are meaningful in some way, such as the swing effects of species interaction reflected in the numbers of unique individuals and what these might signify. The term may also reflect the number of unique types in a defined area hinting at relational effects on numbers but not obviously including them through the additional accounting of “evenness.” Magurran (2004:18) defines evenness as “simply … how similar species are in their abundance,” suggesting a general measure of uniformity between groups, or that all things are somewhat equal. Evenness is also defined as a measure of “the degree to which the number of individual organisms are evenly divided between the different species of a community” (MacDonald 2003:493), the same idea, but one that could be taken as an accounting of the differences in uniformity (an “unevenness”) that suggests dominance of some species over others. This, however, is labeled just that, *dominance* (Magurran 2004:18). It may appear to be unreasonably splitting hairs but the following example hints at the problem. MacDonald (2003:406; emphasis added) cautions that the term “*bio*diversity” is often used to reflect strictly the number of different species in an area (“also called species richness by ecologists”) but any accounting of evenness is not considered.[13] The effect of this apparently less inclusive “diversity” is the elimination of how species interact and how community dynamics impact the actual numbers, the interactions that contribute to the numbers in the first instance. In this respect, species “diversity” and species “richness” are identical qualities with both suggesting only a species

[13] MacDonald (2003) defines biodiversity broadly as the number and variability of living organisms. It is often defined as the number of different species in a geographic area. “The greater the number of species present, the greater the biodiversity (486),” whereas, “in many large scale biogeographic studies, biodiversity is synonymous with species richness” (407). It is the same but the scale can be vastly different.

list or inventory. More recent versions of the species-area curve includes curves to model species-abundance distributions (SADs). Scheiner et al. (2011) write of species-richness relationships (SRRs), another more recent distinction for what has been typically presented as SARs. SRRs are defined as "descriptors of various aspects of *inventory* diversity [alpha, beta, and gamma diversity] that do not include, 'degrees of differentiation [beta diversity] between two different habitats or communities' or, the turnover in species" (MacDonald 2003:485; emphasis added). Alpha diversity is the degree of difference between species found on different sites of the same habitat and gamma diversity is an estimated number of species over large areas. They are SARs with a particular focus. (For an archaeological explanation, see Lepofsky and Lertzman's [2005] discussion of archaeological equivalents of ecological concepts of diversities and an analysis of species-area curves for archaeology.) These concepts can confuse what is essentially an accounting of variety strategy ("richness") based on selected categories of richness, the SAC approach having its own definitions of what constitutes the richness of ancient deposits.

The literature of species-area curves and species-area relationships often uses the terms "diversity" and "richness" interchangeably, "richness" seen as an accounting simply of "presence" or the occurrence/observation of particular taxonomic types. However the terms are defined or used, both are selective measures. As in our analyses of ancient remains, it is not possible to account for all "types" and decisions are made to ignore some and account for others. This same selection occurs in ecological diversity studies perhaps focusing on the most dominant or abundant species and eliminating entire taxonomic categories such as all insects or grass-types, excellent examples of challenging species to identify and quantify that may be excluded depending on the focus of a study. Generally, diversity in archaeology refers to the accounting of "variety," or "presence" as in the number of different types or unique taxonomic categories within an artifact class. Because so much of archaeology is involved with fragments, while we borrow terms from ecology to talk about archaeological and archaeobotanical content, the expansive form of diversity that includes some measure of abundance does not fit well because it implies something we cannot state with certainty.

We often use the term, diversity, as a convenience for talking about uniformity of distribution or densities and how common certain artifact "types" occur or, occur in comparison with others (an "evenness" or dominance measure for sure but ones fraught with biases). Compounding the fuzziness of the whole endeavour, we do indeed account for qualities of evenness/abundance/dominance, but in the interpretative phase of analysis. We compare unique taxa through "ubiquity" of deposition as a way of talking about trends and patterns of archaeobotanical artifacts across deposits and sites. Here, in effect, it is a comparison of "content," where specimens of biological taxonomic categories (family, genera or species and culturally useful "parts") are compiled for comparisons of how commonly (or rarely) they occur in samples from the same and/or different deposit types. But it is a *sample* ubiquity, although often not described in this way. Relative abundance measures serve a similar purpose of mitigating for the problem of how to count archaeological artifacts by comparing the apparent abundance of one type to the apparent abundance of another, that is, “relative abundance.” The archaeological reality, however, is one of fragmentation, a problem that impacts the effectiveness of STR strategies.

Pearsall (1988; 2000:242) cautions that the assessment of abundance and how to account for fragmentation requires critical analysis. Samples are usually subsampled to some degree although often detailed methodological information is vague or lacking, the fault likely due to our emphasis on broader statements of plant use and assumptions of standardization. CCAC requires the examination of particle-sized remains to a minimum of .25 mm in size to capture evidence of wild and weedy species, species that often have minute seeds. Other researchers limit their analysis to a minimum of 1 or 2 mm in particle size. The smaller the material analyzed the greater the costs (but more information). Changes over time in methods also contribute to differences in focus. Comparisons between such datasets are biased and filter information, contributing to a false abundance of particular specimen sizes. The problems of how to quantify abundance is most obvious in how we are forced to account for it and still offer meaningful cultural inference; as evidence of a type of category of human action, the use of plants as products for, and of, some activity. While there is an archaeological language around fragments, identities and abundance (e.g. NISP and MNI),[14] I’m avoiding a deeper discussion but provide an example here. These measures tend initially to confuse the point of the SAC approach, which is to account for “presence,” the first single observation, whole or fragment, of identifiable new taxa as a sampling strategy, a version of an *SRR* strategy. The approach does not account for abundance *per se* although it is impacted by it. In addition, the less-than-ideal specimens must be ignored in the accounting due to degraded morphology or lack of confidence in identification. It is most appropriate to label the measure an identifiable archaeobotanical richness (aka unique recovered ancient variety), fully appreciating and articulating how much data may be lost

[14] Quantifying fragments (and abundance) is problematic on a number of scales. Lyman (2005:846) provides some definitions for zooarchaeology: NISP (number of identified specimens) is a “simple tally of the total specimens identified as belonging to a particular taxonomic category;” MNI (minimum number of individuals) represents the “number of individual organisms necessary to account for specimens of a taxon.” Lyman provides a telling zooarchaeological example: the accounting of three complete femur bones, one left and two right sides, as representing two individuals, and notes, there are problems when attempting to identify age, sex and size to determine if the right and left bones actually came from the same individual. These methods of accounting are also problematic (and in some cases meaningless) in archaeobotany/paleoethnobotany when considering what “abundance” and “fragmentation” might mean, particularly when the calculation of identified taxonomically specific botanical fragments is highly unlikely to be rigorous enough to represent a particular number of plants or, in the worst case, be identifiable to anything more than “fragment.”

through the process, some of which might be mitigated through interpretation in terms of inferred "use," "abundance" and "ubiquity," or perhaps, not. The following example illustrates some of the challenges of quantifying and talking about archaeobotanical richness/diversity, the character of which we hope to capture through limited sampling.

Archaeobotanical "abundance:" the weedy species example

Taking my cue from Pearsall (2000), abundance has meaning although perhaps not in the sense we might first assume. Seeds are some of the most resilient plant artifacts to withstand deposition, excavation and analysis. Accounting for them in terms of abundance/commonness is still challenging. An example can be seen in the prolific *Verbascum thapsus* L. (common mullein), a biennial weedy plant introduced from Europe and known to be have been used as early as the mid 1700s in the United States (Royer and Dickinson 1999:140-141). I choose this plant as an example because of its historic use by Southwestern indigenous groups and because we rely on ethnographic analogy to suggest inferences of ancient use.

Verbascum thapsus thrives in disturbed habitats such as waste areas and agricultural fields. A single *V. thapsus* plant can produce over 180,000 seeds, seeds that remain viable for a century or more (Royer and Dickinson 1999:140). High seed production and reproductive longevity is not uncommon to many weedy species. The recovery of literally thousands of weedy seeds in a flotation sample may suggest the inclusion of the seeds of multiple plants into archaeological deposits or the result of the seeding of a single plant, content that does not represent human-use abundance but could be easily mistaken for it. It may also reflect the accidental inclusion of unwanted or unrecognized seeds through the ancient gathering of products of agriculture where disturbance species are expected. It may be due to the use of the leaves or roots during a time of seed production. In the case of this weedy plant, if evidence of charred *V. thapsus* (presumed ancient) should be found in archaeological sites before the 18th century, it poses an interpretative challenge. It might be tempting to characterize this species as strictly nonarchaeological. However, its presence in the ethnographic literature hints at possible proxy connections with ancient activity and plant selection choices. Ethnographic evidence indicates that the Pueblo people of Hopi, Zuni and Isleta among other North American native groups used the leaves of *V. thapsus* historically. Moerman (1998:591) compiles documented uses that include ceremonial tobacco, anticonvulsant medicine and relief of "witchcraft" and unusual behaviours, conditions and realities that are likely to have persisted through time. In such a case as this, the species may represent the more recent substitute for ancient medicine or tobacco of a similar kind if the ethnographic record reflects a long-standing association of similar plants for the same purposes. Can we infer links to this type of usage based on similar biological properties characteristic of other plants? If the seeds are fragmented it is not unreasonable to suggest that they were intentionally modified as a direct or indirect result of some human purposeful activity. *V. thapsus* seeds have very distinctive surface characteristics and morphology that are easily distinguished and not easily unidentified. The question becomes how these specimens can be accounted for in terms of ancient deposition. How will fragmentation be measured being associated not only with human action, but also with depositional effects? One assessment is culturally meaningful. Does the evidence reflect the preservation of abundance, abundance of use, simply an accident with a single plant, or modern contamination and where does that dismaying potential leave the integrity of the deposit? How many fragments are representative of a single seed and does it matter?

An additional complication in this example is the size of the seeds of this species, which at less than 1 mm in length and 0.5 mm in width would typically be found in the smallest of light fraction screens, screens that are routinely subsampled. Accounting for abundance and use in a meaningful way for this plant and other weedy species may be of questionable validity. The less-than-ideal bits and pieces fragmented or degraded to an extent that suggests morphological similarities with family, genera or species are ambiguous enough to erode confidence in identification. Added to this, fragmentation likely reflects real abundance of use—processing. An analysis relying on a database of unidentified or undescribed fragments without reference to further detail will contribute to the invisibility of the remains.

As the example suggests, richness of a sample and abundance of unique parts in addition to the quantity of both modern debris and ancient degraded fragments impacts how the SAC approach functions, imposing effects on subsampled volume. Abundant microscopic material will create a higher (denser) volume, a larger "area" of analysis within a single litre sample or light fraction screen. Larger sized particles, such as rocks and twigs, create less. Different samples from the same deposit can have very different compositions. The "area," as in the "species-area" or "species richness" relationship, varies between samples. The subjectivity of observations also impacts these measures of richness. Dods (1998) notes that we recognize taxonomic distinctions based on deliberate assessments *and* inadvertent decisions. Both serve as filters that remove information and contribute to data loss. We identify plant remains through observations of distinctive morphologies that match the general characteristics of particular known biological entities (family, genus, species, etc.) but the data consists of the recognition and nonrecognition of certain plants or plant parts both as biological categories and "used" categories. Here again, the *V. thapsus* example suggests that we filter based on decisions about usefulness and potentials as we subsample and some specimens get lost in the process. These are observations that become transformed into inferences that may or may not suggest "absence," "abundance," "fragmentation due to use," and "presence." The ideological and physical world of the past represented in fragments so typical of the botanical record, further reduced through the process of recording, creating and plotting "data" (Dods 1998:288-301). Regardless of these well-acknowledged complications of accounting for plant remains, the most sought after goal is the *representative* sample within these confines. A similar goal is tackled in ecology through this plotting of species data and the creation of curves that purport to identify species "asymptote." The evidence I present in the following chapters suggests that asymptote is also a problematic concept for archaeobotanical sampling.

Asymptote

Ecological richness/diversity is measured through the identification of what is commonly termed "species asymptote." Asymptote is rarely described but used extensively and purports to identify the point of species richness/diversity of a defined ecological area ("habitat") through the plotting of curves and the relationship of the plotted curve to a horizontal line. Williamson et al. (2002:1713) state that asymptote is "a standard and well-defined concept," although I have not found this to be so. Asymptote is detected when species observations are graphically plotted and is calculated by statistically fitting a line to the datum points. The point at which a rising line curves to horizontal or close to horizontal falling in line with the x-axis of a graph or plot, indicates asymptote—when new species are no longer encountered or are becoming very rare (or rarely observed)—and thus, "species asymptote" is assumed. The line does not identify an individual last new species in this respect, but rather provides a statistical estimate of richness, a reasonable generalization based on plotted and sampled data.

The origin of the word asymptote may have come from the New Latin, *asymptotus*, meaning "not meeting" and was first used the 1600s (Merriam-Webster 2014) and is defined in mathematics as,

> a line or curve that acts as the limit of another line or curve. For example, a descending curve that approaches but does not reach the horizontal axis is said to be asymptotic to that axis, which is the asymptote of the curve **(**Encyclopedia Britannica on line).

Asymptote, then, reflects the curve of a line as it flattens in relation to another line. Species numbers become asymptotic to a certain area plotted when numbers no longer increase as additional area is evaluated. Lomolino (2000:18) notes, "the species-area relationship should asymptotically approach or level off at…the maximum value of richness." Lomolino (2002) links asymptote to "a boundary." Williamson et al. (2001; Williamson et al. 2002:1713) suggests not only does asymptote *not* exist in ecology but also that as there is a finite number of species in any area within a time frame and what has been identified as "asymptote" is simply this point. It is a measurement of sampling effort (see

Lyman and Ames 2007). It is a measure within a slice of time. It is also a point that is used to suggest maximum richness, one that does not require the statistical estimate of richness but a "simple" accounting of variety (see Figure 3.1, p. 61). SARs are affected by distance, habitat, climate, history and sample size—key issues imposing effects on what is being measured or modeled—so "maximum richness" is itself contingent (Williamson et al. 2002:1713). Regardless, the word is used to represent some measure of maximum richness and may end up being a number, such as a cumulative count of species variety, which generally indicates a point where observations of new species cease or taper off to an acceptable degree for a sampling strategy, one that no doubt captures an estimate of some measure of the greater population. It is important to consider that asymptote is a concept that beyond being a statistical estimate, an identified point and a curving line, has a great deal to do with the mechanisms of acquisition and how much sampling effort is required to capture it, "it" being, in the simplest world (mine), presumably the last new species (in effect, the last new species to be *observed*) or somewhere close to it. The effort is a measure of area sampled, time taken to do so, and the general richness and area of the population. The idea of species asymptote in its least complicated usage, "maximum richness or close to it," can be seemingly identified whether plotted on a graph or not. Just keeping a list will accomplish the task because the point is identifiable when no new species are observed over multiple samples. This point also indicates when further sampling appears to be redundant. So, asymptote suggests both the point of maximum richness *and* redundancy, two sides of the same coin and serves as a handy timesaver word for conveying some sense of richness represented in a sampling frame. It also appears to have the additional quality of identifying the smallest area required to adequately represent diversity or richness of a particular habitat. This is referred to as a "minimal area" and is used as a standard applied to similar habitats as a way to manage ecological sampling and postulate representative and ecologically meaningful data. These qualities have come to be understood theoretically and mathematically through diversity studies. Caution is required, however. Researchers have found that some habitats and taxa do not conform to asymptote (the leveling off of a curve). The data are sample-dependent (Hayek and Buzas 2010:259). Considered by Williamson et al. (2001:827) to be a "wide-spread myth" in the species-area debate, its counterpart "redundancy" then, must also reflect a problematic plateau when assuming representative samples. Accounting for diversity and the asymptote concept are explored further through a review of the theory behind, and historical background of, SARs.

Measuring diversity: theoretical underpinnings of the species-area curve

From as early as the late 1700s, observations of increasing species diversity/richness were noted across geographic area (Forster 1778; Wallace 1878 in Gotelli et al. 2009:874) prompting later scientists to formulate models and mathematical equations for what early in the 20th century came to be known as the species-area relationship. Accepted as an almost universal law in ecology, the theoretical foundation that underpins the concept of the species-area relationship, often simply referred to as the species-area curve, is the persistent pattern associated with diversity. “Too common for anyone to say they are accidents,” occurring as they do at multiple scales, this pattern occurs at the individual species scale, at different scales of area and in different geologic timeframes (Rosenzweig 1995:4). Considerable evidence from ecological and biogeographical research suggests that the SAC approach is founded on well-entrenched mathematical and statistical regularities.

Historical background

The patterning of increased species across geographic area is repeatedly observed in nature (McGuiness 1984). Drakare et al. (2006:215-216) write that SARs “are among the most widely studied phenomena and robust generalizations in ecology.” An array of studies demonstrates this effect, although the mathematics and the terminology may vary. The concept of species-area has been used as early as 1835 (Rosenzweig 1995:8), its most enduring model, the mathematical equation formalized as the “species-area curve,” introduced by Arrhenius (1921; Scheiner et al. 2011:197). Gotelli et al. (2009:874) note that over 100 ecological and evolutionary hypotheses have been proposed to explain the patterns. The classic model of the species-area relationship is MacArthur and Wilson’s (1967) theory of island biogeography and “famous crossing curves” (Wilson 2001:vii), curves fitted to species data that plot species immigration and extinction rates to account for diversity patterns on islands. MacArthur and Wilson (2001 [1967]) found that various scales of area influence species diversity based on size of islands, the distance from species source habitats such as larger islands or continents, and species rates of immigration and extinction. The theory of island biogeography not only revolutionized the concept of diversity but also fully entrenched the use of mathematical models to explain it. The isolated sampling frame of “islands” as a type of well-bounded space is useful in diversity studies for many discrete habitats. The method of recording and plotting observations of botanical diversity suggests utility for managing sampling of well-bounded archaeological deposits where we can postulate on single last use activities (thermal features), and accumulations of debris (as in middens).

Research into species-area relationships continues in ecology today (He and Legendre 1996:719; see also He and Legendre 2002 for an in-depth discussion) falling under what Holyoak et al. (2005:2) term “diversity theory,” reflecting the many ways that diversity is measured and understood, attesting to continued and sometimes contentious debates. The focus of many studies is whether the species-area pattern, “the curve,” represents important mechanisms of species interaction and/or environmental effects. Interpreting how the data reflect increasing diversity with sample size invariably follows (Rosenzweig 1995:190-192). Increased diversity, an effect that is particularly true of large geographic areas, or "mainlands," supports three essential hypotheses in ecology:

1) Larger areas have more individuals and *thus larger areas require increased sampling effort*.
2) Larger areas have more habitats with *"area" being a defined concept, a "finite sample* of geography."
3) Larger areas contain more biogeographical provinces [diversity of habitats, etc.]. Biogeographical provinces contain unique taxa reflecting mechanisms of evolution at many scales (Rosenzweig 1995:190-192; emphasis added to highlight sampling conditions and biases).

The purpose of species-area analysis is to meet the overall goals of ecology, which are to measure, understand and predict patterns of biodiversity (Holyoak et al. 2005:1). They also serve to model sampling effects. Species diversity and richness assessments may be negatively constrained by the scale at which they are measured. Sampling decisions will impact how the numbers are acquired and how species-area relationships are quantified and understood. The mathematics generated by species-area data purport to suggest universals, some of which are seemingly species/habitat specific; the process, seen as predictable.

The mathematical foundations of the species-area concept

By 1972, Whittaker wrote of "a new ecology," inspired by the early work of MacArthur (1957) and the increasing use of mathematical approaches for understanding diversity,

> a different kind of ecology, one of an orderly, formal system of mathematical relationships by which diversities and the importance-value relations of species should become predictable (Whittaker 1972:214).

This mathematical trend definitively had its roots in Arrhenius' (1921) model sparking the beginning of quantitative ecology (Drakare et al. 2006:216). Mathematical functions are seen as "useful for characterizing observed patterns" in ecological diversity studies (Harte et al. 1999:334). Formulas that appear to be congruent across multiple datasets should indeed suggest typical patterning. By factoring in the habitat conditions, the rate of speciation, population dynamics, energy flow etc., and a picture of the nature of diversity should become reasonably apparent. The possibility that a single mathematical model might prove to be universal fits with the goals of diversity studies that aim to explore how diversity operates: when area increases or decreases such as in loss of habitat, the mathematics estimate or predict when a full complement of diversity or the tipping point of maintaining a defined measure of diversity, is reached. The idea that a minimal area, a constrained area or sampling situation, can still capture the content of a larger population based on these mathematical regularities is extremely useful. Curves seemingly demonstrate this quality, some better than others.

Arrhenius, whose work was based on island community plant species, like MacArthur and Wilson, understood the importance of islands as uniquely bounded spaces for analysis of diversity. Beyond providing results that confirmed "the well-known and obvious fact that, the larger the area taken the greater the number of species," his formula allows for calculations of species richness for discrete vegetative stands without full survey (Arrhenius 1921:95-99), written as $S = cA^z$. S represents species richness, and A is area sampled, c is a constant that is "based on the number of species per unit of area in the geographic region in which the study is conducted" (MacDonald 2003:407) and varies by orders of magnitudes (Lomolino 2000:17). The constant z or slope of the line (the species-area curve line) represents "the mathematical relationship between area and species richness" (MacDonald 2003:408) and "varies according to the topographic diversity, the isolation of the area and the mobility of the taxon" (WICE 2014). Arrhenius' model is a "predictive equation," a log-log, power, power function, power-curve or power-law model of species distribution (the labels are interchangeable), the plot of which both x and y values are logarithms (Hayek and Buzas 2010:69). It does not give "exact answers" but can allow for reasonable estimates for comparisons (266). "Many empirical quantities cluster around a typical [mathematical/statistical] value," the pattern seen in a "diverse range of natural and man-made phenomena." From the populations of cities to the intensities of earthquakes (Clauset et al. 2009:1), there are regularities in these phenomena as well.

The common patterning seen in plotted curves, the "steeply rising line that tapers off," led not only to ecological theories, but later to other specialists, including statisticians, fitting probability distributions to explore which distribution might best describe the pattern (Preston 1948). Many have been shown to fit quite well (Hayek and Buzas 2010:174). The normal distribution (the symmetrical bell-shaped frequency distribution of probability statistics) theorized as "a law of nature" was accepted for some time, but is an assumption now known to be inaccurate although one acknowledged to provide a "reasonable approximation" of nature where some habitats contain species that are extremely abundant, a few species are very rare, and many are reasonably common (25; 201). Or, to think of it another way, habitats of certain types provide the conditions and diversity required to accommodate species variety (species richness).

Hayek and Buzas (2010: 201) caution that, "we cannot fit a normal distribution, which is a continuous distribution extending from very large positive to very large negative numbers" in diversity studies. A half curve is required and thus the need for logarithms and "truncated" distributions. This is what the species-area curve approach reflects, a half-curve that purportedly accounts for common tapering to rare species. The power of Arrhenius' power-law mathematical sequence model is that datasets showing a skewed statistical distribution can be transformed through the use of logarithms that reduce or eliminate the skew when fitted to an approximate normal bell-shape, thus creating a lognormal distribution. The lognormal distribution is theorized as describing the abundance of species (Williamson and Gaston 2005:417) suggesting to me that "nature" displays a normally distributed logarithmic pattern of diversity where a few species are overly plentiful, few are rare, and many more are simply common in terms of abundance. But keep in mind, abundance reflects how common a species is, its density being the differences in abundance of the species per unit area (MacDonald 2003:71). It all depends on the variables plotted. Because the collection of data has a "cut-off point," or the end of sampling, the curve is a truncated distribution or a truncation of a probability distribution, and it is extremely complicated to calculate (Hayek and Buzas 2010: 201) representing only a part of the statistical and ecological picture.

Magurran (2004:36; emphasis added) explains the problem of the species-area concept well: "like its normal sibling the log normal [sic] distribution is a symmetric, bell-shaped curve. If, however, the data to which the curve is to be fitted *derive from a sample*, the left-hand portion of the curve, representing the rare and hard to sample species, may be obscured." The larger the sample or the area (to the point of being a biogeographical area) in combination with long periods of extensive sampling in terms of time and effort, will capture those rare and harder to find species to mitigate for this effect (36). These are "area" curves, randomized data not ordered data─the data plotted as it is observed. In addition, Arrhenius' species-area model is not the only option, there are numerous! Tjørve (2003:827-828; emphasis added) notes that Arrhenius' power curve and other proposed curves have "convex upward shapes and are not asymptotic," and that "they might not be fitted successfully to data from very small or very large areas."

It is not uncomplicated. Rosenzweig (1999:276) attributes Preston (1948) as "proving," albeit incorrectly, that "a certain type of log-normal [sic] distribution implied a species-area relationship that came quite close to Arrhenius' S = [c]A^z with a z of about 0.26." Preston's (1948:283) z value was around 0.2, later recorded that it "should be 0.27 approximately" (Preston 1960:612). This number and Arrhenius' "0.26" became increasingly important in the species-area debate as ecologists struggle to find and understand the species-area relationship's mathematical and statistical regularities. Rosenzweig (1999:276) cautions that "species-area relationships with z-values strikingly different from 0.26 kept popping up," (with values typically falling within the range of 0.10 to 0.50) calling into question if a diversity "number" or standard can ever be assumed (Lomolino 2000:17). This effect is patterned also, "larger scales of space *and time* generated species-area relationships with larger *z*-values" (Rosenzweig 1999:276; emphasis added). The lower the *z* value overall, the less area needed to capture the greatest number of species, usually being higher for islands and lower for mainlands (WICE 2014). Implicit in "size" is the time it takes to measure diversity, which is, in effect, the time it takes to collect and use the data (Preston 1960; Lyman and Ames 2007). Time, as Preston (1960) acknowledges, plays a role in contributing to, or decreasing diversity measures, as much as it plays a role in sampling effort. It is not simply a case of "large" vs. "small" samples, large having a better probability of a normal statistical distribution. Sampling bigger areas takes greater time and the effects of time can be seen in naturally occurring *succession, speciation and extinction during large ecological sampling projects,* impacted by something as "simple" as the sampling season! All contribute to how SARs are modeled. On the smaller "archaeobotanical" scale we see time in terms of sampling effort and the time it takes in the laboratory, but time has an additional effect of sampling a slice of *ancient time* much as it samples some measure of ecological and anthropological "activity." Thus, we may inadvertently sample new and unconnected temporal and spatial material. These are biases that are accepted as largely irresolvable and unavoidable. Most importantly, we are not calculating diversity; we are observing a pattern and relying on theoretical distributions of diversity to support a concept of representativeness and "asymptote." The pattern is supposed to tell us when sampling becomes redundant.

The original intent of Arrhenius' mathematical formula was "to describe the increases in species numbers found as the size of the sampling area increases." It offers hope of a convenient tool to talk about species and habitats but not to "provide biological explanatory power" (Tjørve 2003: 828). And, it has proven to be over simplified (Rosenzweig 1999:276). The abundance problem or, how abundance impacts diversity, was not immediately evident in the early SAR work, having as it does, the function of increasing species resilience and/or contributing to additional speciation thus, increasing or decreasing the chance of being observed resulting in higher or lower diversity calculations. This leads to the immediate dismay of having to calculate the mathematical regularities of species-specific abundances to make it all work, hence "SADs." Williamson and Gaston (2005:409; emphasis added) report that the central limit theorem[15] predicts lognormal distributions for SADs only in some instances. These are in abundances *within* species, not *between* species, a cautionary statement about diversity, evenness/relative abundance and densities. Regardless, the species-area curve has provided the mechanism by which data can be used to demonstrate a relationship graphically. Its earliest use, the one archaeobotanists have been most interested in,

[15] The central limit theorem, a statistical proposition, states that the larger a sample size, the more closely the sampling distribution of the mean will approach a Normal distribution even when the population from which the sample is drawn is not normally distributed (adapted from Vogt 1999:37).

suggests that the minimal area or, “the smallest sampling area needed to obtain reasonably accurate estimates of species richness or composition in a community” (Scheiner et al. 2011:197), is useful for finding a stopping point of analysis. The conditions for the effectiveness of the minimal area is the result of random sampling, the requirement of homogeneous habitat and a presumed normal probability distribution or a reasonable enough estimation of normality, where “few species are rare, a few are common, and others abundant.” As described by Mueller-Dombois and Ellenberg (1974) and detailed further in this chapter, the minimal area concept and its attendant asymptote, redundancy, and regularity assumptions are critical to the presumed results of the SAC approach inasmuch as they are critical to the mathematics and statistics behind the species-area relationship/curve, remembering that the data used are captured *through a collection process* not a randomized plotting of data, which in our case, is unique to archaeobotany.

For sampling in archaeology, the importance of ecological SARs does not reside in mathematical equations, although these explain why ecological data apparently plot the way they do (the “sharply rising line...”). Mathematical expressions and statistical analyses might suggest theoretical cause-and-effect in ecology once complexity and biases are factored in, but these are unlikely to easily provide well-supported “cultural” or sampling meaning for archaeologists and archaeobotanists because they require at minimum, huge datasets and unimaginably onerous effort that must be repeated with every new archaeological site. It is the patterning of observations that has been seen as useful: the observation of common species accumulating and tapering off—the shape of the plotted line that supposedly represents the accumulation of common, less common and rare under the impacts of abundance and richness. If species-area equations and statistical distributions are problematic and, as Rosenzweig (1999:276) acknowledges,“the theoretical bubble has burst” on species-area relationships when considering the effects of anthropogenic landscapes and species loss, then what does this suggest about species-area curves, sampling to redundancy, and an archaeological approach founded on these concepts.

The species-area curve (SAC) approach

The SAC approach, like so much of the terminology described here, is a misnomer inasmuch as the “species-area curve” can also be a misnomer. There are numerous types of species-area curves, Scheiner (2003, 2004) describes six different types of SARS (his “mélange of curves”) in ecology, each constructed differently through sampling schemes (nested, contiguous, non-contiguous and island), in addition to whether the analysis method is based on single points or calculated means and the statistical methods applied. All account for species numbers that are founded on theoretical SARs, SRRs, SADs or other configurations of the same idea assuming or claiming outright, a lognormal/normal statistical distribution pattern. An important distinction more recently acknowledged, is that these curves are not necessarily species-*area* curves, as much as species accumulation curves, species effort curves, collectors' curves, species discovery curves or taxon accumulation curves (Gotelli and Colwell 2001; Hayek and Buzas 2010:258; Lepofsky and Lertzman 2005). These curves reflect the method of collection, not a relationship, *per se*, of species/taxa to area (in our case, "volume"). All plot the cumulative number of species against some measure of sampling effort (Hayek and Buzas 2010:258-259; Lyman and Ames 2007:1986). In this respect they are species-effort curves that capture sampling effects. As this suggests, "area" and sampling have been seen as synonymous in many respects, with time being acknowledged as a contributor or bias in later explanations. As the introductory quote of this chapter illustrates, there is a rapid accumulation of information in initial sampling stages as a result of how we sample (Hayek and Buzas 2010:259) which is responsible at least in part, for the sharply rising line. The relationship that exists between the two variables of "species" and "area" is one of a sampling strategy, and a subjective one at that. The SAC approach is best described as a sample-based taxon accumulation method that has specific taxonomic categories of analysis. It is sampling method applied to individual samples (in fact, individual light fraction sample screens) that is founded on the accumulation of observations based on volume. It is rarely plotted and the method limits subsampling only to certain size grades of microscopic material and the apparent redundancy of the effort as subsampling proceeds. It serves to account for some of the botanical richness of a sample not some ancient cause although we interpret a measure of this quality through inferences, but after the fact. It is not calculated statistically or mathematically and it does not rely on either. It relies on a fundamental assumption of a curve that indicates a kind of taxonomic asymptote, otherwise known as "redundancy."

The mechanics of the SAC approach are seen to be somewhat universal, in that, flexibility has been built in to respond to the diversity of samples, the method being applied routinely to different deposit types and sites. Recommendations include the testing of the approach for site-specific conditions to ensure reasonable results. The measure of sampling effort/"area" used in the SAC approach is not the overall volume, the one litre sample, but *the subsampled light fraction volume*. Playing with the language, the capture and plotting of archaeobotanical data reflect an archaeobotanical equivalent to an ecological "survivorship" curve on numerous scales: what survives from the past under processing in both the past and the present that is identifiable and provides interpretable inference value in the final analysis.[16] The aim of the approach, to "maximize the

[16] Odum and Odum (1959) define survivorship curves as plotted data used to explain species diversity in terms of life expectancy of species.

number of taxa recorded while minimizing the volume of sample sorted”[17](Adams 2004:para.25) will, in turn, allow researchers to “maximize the number of samples examined without compromising the potential to assess the taxonomic diversity of any one sample” (Adams 1993a:196). *How?* The assumptions associated with the ecological quantification of diversity in terms of patterns/curves, asymptote, and redundancy are accepted as reflecting a diversity “effect.” The use of species-area/accumulation curves, if not treated with considerable caution (Lepofsky and Lertzman 2005), more accurately reflects the rapid accumulation of information in the initial sampling stages. Distorting effects are compounded by presumptions associated with any sampling strategy where the data not randomized *after* collection but assumed randomized through the process of collection. As demonstrated in a simple species accumulation curve on which the SAC approach is based (Figure 3.1, over), we actually see a collection process.

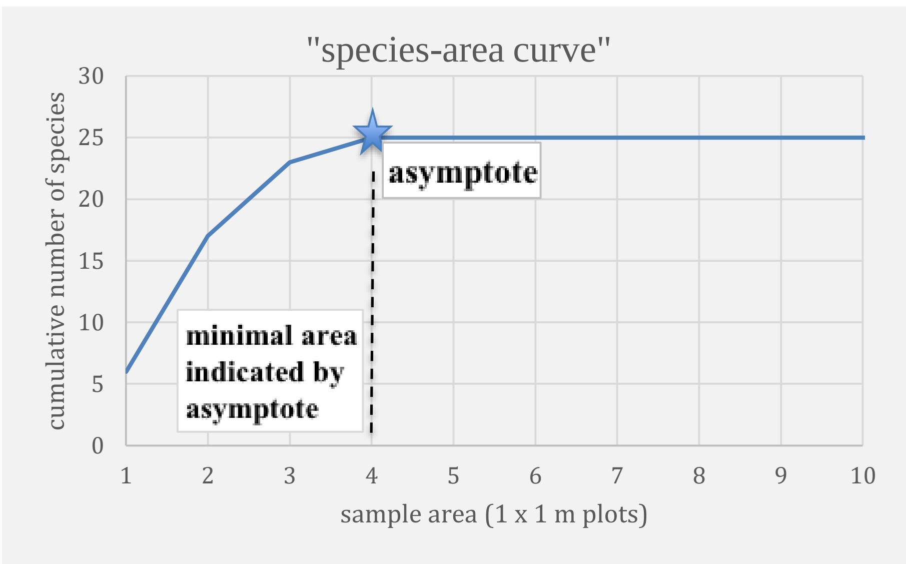

Figure 3.1 A simplified "species-area" curve using a line graph showing individual data points and demontrating minimal area required to reach asymptote (indicated by a star). Figure 3.1 is actually an accumulation curve where the data points are cumulative new species and asymptote represents the “last new species.” This curve demonstrates that, after accumulating 25 unique species, no new species were observed after four 1-x-1 m plots were evaluated. It is assumed that the minimal area indicated by this asymptote can be applied to other samples from the same habitats or populations thus eliminating the need to continually test for minimal area.

[17] The term “sorting” in common archaeobotanical usage encompasses a range of activities applied to flotation samples and can be confusing. Pearsall (2000:100) notes that the goal of sorting is the removal of archaeobotanical materials from rootlets, twigs and other modern debris. In the laboratory, “sorting” can include the division of light fraction remains into geologic screens as an aid in microscopic analysis and the recovery and identification of botanical remains (which may include uncharred material that may or may not be modern in origin) through the process of microscopic analysis. I try to avoid the use of the term replacing it with “screening” and “microscopic analysis” to distinguish between them for the purposes of exploring sampling effects.

Figure 3.1 illustrates the extent of sampling required to reach "redundancy" of sampling effort (that is, the process of accumulating data, not necessarily tied to the diversity of the area under question). In this example, no new species are observed after the analysis of ten plots. As the fitted line indicates, the species count rises rapidly to an accumulated 25 new species indicated by the line leveling off at four $1m^2$ plots. The minimal area associated for the species richness of this sampled population is then four $1m^2$ plots to achieve species asymptote (a *sampled* species asymptote based on the process of accumulating data, often confused with an actual species asymptote reflective of a diversity pattern on the landscape, or indeed, the "representativeness" of a sample). If the line graph reflects the entire population then asymptote indicates the richness of the "habitat" by accounting for the number of different species observed (again, introducing the "subject" into the equation). The assumption associated with this particular minimal area is that it may be appropriate as the smallest area requiring analysis for *other* habitats of similar type. The key characteristic of the graph, of course, is the curvilinear patterning of the line so prevalent in species-area curves that are presumed to indicate the quality of a relationship (how much space required), asymptote, redundancy of the sampling effort and a representative diversity number. The SAC approach relies on the patterning demonstrated: common species are initially encountered rapidly (accumulating to 15 species by the second plot in Figure 3.1) and less common species are gradually added until no new species are observed. This is reflected on the plot as the rapidly rising line that tapers off to horizontal. The effect is assumed to represent common and rare spatial distribution (in reality, a common to rare accumulation pattern). In addition, the flattening of the line purports to indicate a measure of maximum species richness or diversity for the sampling frame that must, based on the fundamental assumptions of the trending asymptotic line, *include some measure of less common taxa*. Less common or rare taxa are important categories for the interpretation of archaeobotanical data. If this ecological patterning holds for archaeobotany, the SAC approach captures a representative sample that also includes some accounting for rare species.

Accumulation curves and "area" curves: similarities and differences

Species accumulation curves are often confused with species-area curves but they are not the same. They are plotted in similar ways and this may contribute to misunderstandings of the intent. The area sampled or variable of interest (in our case, "volume") is plotted on the *x*-axis of a graph, the presence of a new species in an accumulation curve, or the mean number of species in a species-area curve, is plotted on the *y*-axis. A line is fitted to the data. Using an accumulation curve, the line is fitted visually to plot the process of accumulation (e.g. Figure 3.1; Lyman and Ames 2007:1986; Lyons 2000:80; Wolff 1975). Species-area curves, which measure the relationship between the numbers of species over area, require a scatterplot[18] and line of best-fit imposed on data (Rosenzweig 1995:10), a smoothed line that estimates asymptote.[19] Species diversity or richness is then an estimate and mathematical and statistical reasoning can be brought to bear on the results. Regardless of whether the "curves" are stepped as in plotted accumulation data (such as Figure 3.1) or "smoothed" by randomizing the samples and statistically fitting a line, the purpose is to estimate richness of a population using limited sampling.

This difference is confirmed by Gray and colleagues (2004:567) who caution that species-area and species accumulation curves measure "fundamentally different aspects of species richness," representing, in the case of accumulation curves, "the rate at which new species are found with increasing sampling effort," and area curves, "which simply plot the number of species found in areas of different sizes." The term "species-area curve" is "applied somewhat indiscriminately to very different types of data;" and this includes accumulation data (Chave et al. 2002). Accumulation curves measure the rate of accumulated observations of different species in a defined space, and the sampling effort taken to find them where the shape of the curve is the result of *accumulation order* (Colwell and Coddington 1994:105, emphasis added). And yet, they are still often referred to as "species-area curves" (hence my labeling of Figure 3.1 as a "species-area curve"). Hayek and Buzas (2010:259) concur, "the [accumulation] curve…tells us something about collecting effort;" whereas, a species-area curve is a measure of the relationship between the number of species and area over a range of scales, although they too model sampling effort. As in MacArthur and Wilson's equilibrium model where hypothesized reasons may explain the observed pattern of diversity on islands, plotting species-area curves aims to illuminate complex species and environmental interactions depending on the sampling protocol used (individual-based, sample-based, or rarefaction; that is, the application of statistical methods to smooth the curve, a process of plotting "the means of repeated re-sampling of all pooled individuals" [Gotelli and Colwell 2001:380]). Importantly, the identification of individual

[18] Scatterplots/scattergrams are graphs that plot the values of one variable against the corresponding value of another (Field 2009:793). The pattern of the plotted points indicates the strength and direction of the relationship (the correlation) between the two variables (Vogt 1999:256).

[19] More asymptote characterizations: defined statistically as a "theoretical limit that a curve approaches but never reaches, any theoretical outer limit or a leveling off of performance quality or efficiency…[i.e.] a learning curve" (Vogt 1999:14). Asymptote in other applications can simply mean the characteristic leveling-off of a line on a species accumulation graph (Hayek and Buzas 2010:259). In SAC subsampling, ***if*** we used the term and typically we do not, it would reflect the last new species observed and presumably represent the maximum species richness of a light fraction portion. Colwell and Coddington (1994:106) compare asymptotic and nonasymptotic models for species accumulation in what I can only describe as *best left to mathematicians and statisticians.* This may have the effect of implying the "our" richness measures are generated through plotting curves, but they are not. We identify the end of sampling ("asymptote"/redundancy) through the process of subsampling. Curves may or may not be generated.

species is not required for species-area curves (Ugland et al. 2003). The species accumulation curve, on the other hand, is wholly dependent on the identification of species as "unique."

Order of data or observations can reflect a time series or sampling along a gradient or transect. We may presume that order of observation is the same as order of *occurrence*, in a meaningful way and while order and occurrence may be closely linked, this is an assumption. There is a fundamental subjective bias here that confirms Bohrer and Adams (1977:40) nagging question of missing species. Species accumulation curves plot individual species observations where the assumption is common species accumulate first because they are ubiquitous followed by the less common species grading to rare species but this is not necessarily because they are. This is a particular problem for the "rare" category. These "outliers" can be only rarely *observed*. Plotting the data leads to the "sharply rising line" that reflects ubiquitously observed species trending to those that are rarely observed. Thus plotting observations may not reflect actual species distributions (and "rare" species) resulting in a plot of observer bias. Because randomization of sample order is characteristic of ecological diversity studies and a uniform sampling procedure followed, extrapolation is possible because the curves generated "can be reasonably justified as representing a uniform sampling process for a reasonably stable universe" (Colwell and Coddington 1994:106). The order of occurrences in the SAC approach is the essential characteristic of the assessment of species redundancy. This is because it is seen to be a uniform sampling procedure, capture of taxa representing the pattern of "common" accumulating rapidly and tapering off with less common or "rare." It has been suggested that species richness in any situation determines sampling effort, an assessment that depends on the assumption of normal statistical distribution or large samples. The reverse can be equally true: sampling effort determines or biases species richness. The question of what constitutes "rare" and where "rare" occurs in the sampling sequence has yet to be considered.

Sampling for "diversity" in archaeology: the historical context

Archaeobotanists are not unaware of these issues. Sample size, its attendant diversity, and its biases are major issues and continue to be in all aspects of archaeology. Kintigh (1984:44) calls the challenges of archaeological sampling, the "sample size problem." Unique effects are imposed in each sub-discipline of archaeology. Archaeological research often reflects the influence of ecology and various aspects of representative sampling, sample size and sampling effects have used ecological principles to address archaeological problems.[20] Research on sampling effects has been done in

[20] A sample of archaeological study in assessing measures of diversity or general quantitative analysis in archaeology include those of Baxter (2001), Bellhouse (1980), Binford (1964), Cowgill (1964, 1989), Fish and Kowalewski, eds. (1990), Hardesty (1980), Kintigh (1984), Leonard and Jones (1989), Limp (1974), Meltzer et

archaeofaunal studies, which shares the same kinds of sampling challenges as archaeobotany. Issues of fragmentation and similar constraints on identification are perpetually present (see Lyman 2005, and also footnote 14 page 49).[21] Since the advent of flotation—both a boon for archaeology and the cause of additional sampling problems—various experimental studies and assessments have addressed the "flotation" effect as it relates to representative sampling to try to account for biases.[22] A variety of studies have looked at factors such as contamination, depositional and disturbance on deposits, as well as methods to address a variety of limitations in archaeobotanical analyses (Keepax 1977; Miksicek 1983; Minnis 1981; Neumann 1978). More recently, evaluations of sampling effects, effort and richness measures, including in some cases, the species-area relationship, have been examined (Cochrane 2003; Lee 2012; Lepofsky et al. 1996; Lepofsky and Lertzman 2005; Lepofsky and Lyons 2003; Lyons and Orchard 2007; Lyons 2000). Lee (2012) and Orton (2000) recognize that sampling in paleoethnobo*tany (and archaeobotany) represents cluster sampling, a strategy noted early by Cowgill (1964:468) as more applicable to archaeology. The sampling problem of trying to capture representative samples is far from resolved. Regardless, the idea of a sampling to redundancy strategy that capitalizes on well-entrenched ecological principles makes practical sense.

As early as the 1970s, sampling to redundancy and plotting data were seen as ways to achieve or support the idea that representative samples could be achieved. Wolff (1975 in Lyman and Ames 2004:331) made use of sampling to redundancy and accumulation curves in an analysis of Late Pleistocene fauna at the Rodeo sites in the San Francisco Bay area, one of the first studies of its kind. Wolff identified a specific volume of 45 kg of ancient sediment as his sample volume (final tally, 1200 kg in total). After flotation, separating by particle size and microscopic study, the sample volumes and identified taxa were plotted on genera accumulation curves. Groundbreaking for its originality and broad scope, Wolff found that the enduring pattern described in species-area research also applied to his data. The common taxa were more likely to be encountered in first samples with recovery of new species declining as sampling proceeded, although this did not occur in all cases. New genera were encountered after the majority of accumulation curves had appeared to reach

al. (1992), Mueller, ed. (1979), Orton (2000), Plog and Hegmon (1993), Rhode (1988), VanPool and Leonard (2011).

[21] For examples of sampling in archaeofaunal studies see Cannon (1999, 2001), Casteel (1976), James (1997), Lyman and Ames (2004), Zohar and Belmaker (2005).

[22] Flotation studies include work done by French (1971), Kaplan and Maina (1977), Lennstrom and Hastorf (1994; focusing on context and sampling), Rossen (1999), Schaaf (1981), Shelton and White (2010), Wagner (1982, 1988) and Watson (1976).

redundancy. In his study, the process required the management and analysis of an enormous volume of debris.

Adams (1993a) first documented the species-area approach for her analysis of archaeobotanical samples from the Duckfoot site, a Pueblo I[23] site and CCACs first major research project (Lightfoot and Etzkorn 1993:xiii). Now formalized as a method (Adams 2004), other species-area research in archaeobotany has been done by paleoethnobotanist, Dana Lepofsky, of Simon Fraser University. A particularly important study focuses on statistical applications (Lepofsky and Lertzman 2005). A number of Master theses from British Columbia have experimented with subsampling for remains such as wood charcoal (Lyons 2000; Wollstonecroft 2000; Nicolaides 2010). Lepofsky and Lertzman (2005:178) note that use of sampling to redundancy approaches is standard practice for the collection of representative botanical samples in North America and Europe. As far as I am aware, the SAC approach (Adams 1993a, 2004) is the only standardized strategy published in North America.

Capturing archaeobotanical richness: the mechanics of the SAC approach

The species-area curve (SAC) approach uses an accumulation method to limit subsampling of only specific particle sized light fraction portions (the 1.4, .71, and .25 mm screens) confined to those samples that yield greater than 50 ml of total light fraction. Any sample of this volume and greater can impose huge time commitments and can be conceptualized as representing "large" volumes requiring greater than reasonable effort depending on the content of sediments. The data are not pooled and re-sampled to suggest universal patterns or mathematical regularities. The approach is a tool that relies on the assumption that the increase in richness is seen as sampling area increases and observations are patterned in a particular fashion: common species accumulate (are observed) rapidly and abundantly in the initial sampling phases and taper off as observations of new species become rare. Asymptote in one sample is assumed to be applicable in similar samples from the many sampling pools, deposits, sites, etc., because there is some flexibility built in to achieving it through increasing the size of the minimal volume analyzed. The approach can be adapted to site-specific conditions using this flexibility assumption. It is thought that the diversity (the degree of variety) of

[23] Pueblo I is an Ancient Pueblo cultural manifestation reflecting the transition from pithouse to pueblo residency between earlier "Basketmaker" traditions and later characteristics as set out in the Pecos Classification. Dated from A.D. 750 to 900 in the Mesa Verde region, Pueblo I is characterized by the use of cranial deformation, the building of rectangular masonry villages and the creation of gray pottery with neck banding (Wilshusen 1999:196).

ancient material within the sample will be indicated by the rapidity and abundance of new observations, which would impose additional minimal volumes and sampling effort.

SAC approach foundations

Seen as robust enough to be used for or adapted to, a variety of depositional contexts, the SAC approach purports to allow richness comparisons with other flotation samples. The area under analysis in the SAC approach is *volume*. There is no obvious inherent anthropological, temporal, or ecological meaning that can be applied to how species capture occurs in particular screens other than to presume that it demonstrates the common patterning noted in species-area and species accumulation curves. The approach addresses sampling through the analysis of a similar calculated "plot" size, in our case the subsample volume, and adapts by calculating what I term a "flexible minimal volume" that aims to respond to the apparent richness of various size graded portions of light fraction. Two concepts that are indirectly incorporated into the approach detailed in Mueller-Dombois and Ellenberg's (1974:45-66) species-area discussion are *relevé* analysis and "minimal area." Both provide mechanisms that capitalize on bounded sampling frames.

The *relevé* method

The *relevé* method is a technique used to describe a uniform vegetative stand by sampling plots without sampling entire areas (Braun-Blanquet 1932). The term *relevé*, the French word for "list," reflects a list of plants noted in a discrete plot or measured area of vegetation (Benninghoff 1966:109). The method incorporates more ecological data than a simple species list however. *Relevé* includes detailed information about species cover and abiotic features associated with an ecological area. Benninghoff (1966) describes the method as a system of data collection that also captures elements of "sociability" and "vitality" of vegetation through detailed descriptions of species-specific community structure and vigor. Counts of species richness within the specific vegetative community are reported by height (Minnesota Department of Natural Resources [DNR] 2007:1) and includes context by accounting for major environmental features, geographical location, altitude, aspect, slope and substrate. By increasing plot size or number of plots studied, additional data can establish more comprehensive species lists or to monitor area vegetation generally within the larger ecological context (DNR 2007).

Mueller-Dombois and Ellenberg (1974:51) note of *relevé* analysis that, "there is no advantage in increasing the sample size if it yields no further species." The same holds true for archaeobotanical sampling. Redundancy is to be avoided where time and effort can be better spent analyzing additional samples. Interpretation of archaeobotanical data also resembles the depth of analysis associated with *relevé*. Archaeobotanical richness measures are situated in context that provides lines of evidence for interpretation that far exceed the idea of a list, although on the surface, it may appear to simply account for one. It may be useful to interpret one firepit as containing more "diversity" versus another. However, the value of that comparison lies in the details: the temporal placement, the spatial setting, inferred group association and human use, the possible whys and wherefores of the diversity number. A *relevé* study, much like the analysis of data from flotation sampling is concerned with details, although both are constrained by similar subjective and objective decisions of sample size and frame based on research goals (DNR 2007:2). The selection of a *subjective* plot placement for a relevé involves sites where the composition of the community is already fairly well known and plots are selected for a degree of species representativeness prior to the generation of any list. The result is less time in sampling effort because much is already known about the composition of the area. Much like selecting thermal features for analysis in archaeobotany because we understand them and know that they tend to be productive, a subjective ecological plot is selected from a well-understood natural environment. Because it is subjectively selected, data generated are not suitable for analysis of statistical significance. However, the strategy is important in maximizing potential recovery of rare species, rare often being underrepresented in ecology (3). Plots selected *objectively* are experimental in nature. Because they are randomly or systematically selected, the data are robust enough for statistical analysis (3). Central to the *relevé* method is the quantification of a "minimal area" and this concept too, has implications for the capture of a representative archaeobotanical sample.

<u>Minimal area and species-area plots</u>

The minimal area concept (the four 1-x-1 m plots shown in Figure 3.1, p. 61) is a cumulative sample plot size calculated in one sampling study that can be reasonably applied to another. Mueller-Dombois and Ellenberg (1974:47) describe minimal area as "the smallest area on which the species composition of the community in question is adequately represented." Plotting species-area curves, or species accumulation curves, is thought to demonstrate the size of a minimal area and thus "asymptote" (Hopkins 1957) or, as He and Legendre (1996:719) describe, "the shape of such curves has been used to help determine the area required to obtain an adequate sampling of the species in a particular community." Minimal area will be reflected on species-area or accumulation curves at the point where the curve becomes approximately horizontal (Mueller-Dombois and Ellenberg 1974:48; Hopkins 1957). Early in ecological research, the size of a minimal area was known to vary considerably for different communities (Cain 1938:573).

The SAC approach provides a standardized "minimal volume" for subsampling light fraction particle sizes that has been tested. That is, for the 1.4 mm and .71 mm light fraction particle sizes, the minimal volume of material analyzed is standardized to 2.70 ml (or three consecutive "plots" or subsamples of .90 ml) if no new species are encountered within that volume (Adams 1993a; 2004). If new species are encountered, the volume is applied again to accommodate for the apparent richness of a particular sample screen. This flexibility allows for increased minimal area in respond to the richness of a particular sample. For the smallest examined specimen size, the .25 mm screen, minimal area/volume size is calculated as .9 ml of material or, three consecutive "plots"/subsamples of .3 ml each. The SAC "plot" sizes are based on ease of analysis, the quantity of material that can easily be viewed under the microscope based on particle size (Bohrer and Adams 1977:40) in an attempt to limit refocusing time.

The type of sampling strategy in ecology, whether it be sampling contiguous plots (the nested plot design) or sampling randomly, affects the steepness of the slope of a line when plotted (Rosenzweig 1995). Random sampling produces steeper species-area curve slopes, meaning the typical pattern of accumulation of common species will rise more quickly, showing a steeper slope to the line on a graph. The accumulation of rare species presumably stops more abruptly, requiring less area to achieve asymptote. In the SAC approach, subsampling follows a particular process that could be argued as both a contiguous and nested plot design, depending on how the data from the accumulation method are actually used: as a measure of particle-size richness for a single screen or sample (i.e., defining the universe from which it was taken at the sample scale) or, as a contributing measure of deposit richness (defining the universe of the entire volume as a measure of the deposit richness). In this respect, all larger screen sizes are included as cumulatively contributing to the richness of the sample, or in interpretation, the deposit. A description of the SAC technique is re-iterated from chapter two and described in detail as follows:

<u>SAC subsampling procedure (adapted from Adams [2004])</u>

For each of the three particle size screens subject to the SAC approach (the 1.4, .71, and .25 mm screens), the following process is used to subsample.

- Each of screen is analyzed to the limits of the approach before moving on to the next smallest screen size, beginning with the 1.4 mm portion.
- The light fraction for that screen is poured into a large graduated cylinder. From there, the material is poured into a smaller graduated cylinder until .9 ml is measured off. This volume is then placed on a marked plate and scanned in transects under the microscope for identifiable taxa.
- Taxa are documented and removed from the subsample, labeled and stored.
- A second subsample of the same volume is measured and examined.
- The process is repeated until three consecutive subsamples yield no new taxa.

At this point the taxa identified are thought to represent an archaeobotanical asymptote for that particle size and the portion then deemed adequately represented in terms of taxonomic richness and further effort redundant for that screen. The next smallest screen (.71 mm) is viewed using the same minimal volume (of three .90 ml subsamples) following the same technique. The smallest screen (.25 mm) is subsampled in .30 ml increments in the same manner. The subsamples are contiguously sampled by screen although the portion itself is nested as is the entire sample.

The use of the SAC approach, like ecological species-area curves, assumes that all species "in the system (or a high percentage) are actually observed in the samples" (Shmida and Wilson 1985:3). This assumption could be rewritten as: the SAC approach assumes that all preserved and identifiable botanical remains that resist damaging effects from flotation are present and observable in the processed samples.

Richness distinctions using the SAC approach

The SAC approach aims to capture the ancient botanical richness of individual samples but has categories associated with how richness is defined. Identification is based on observations of non-ambiguous morphological characteristics most often observed at the family or genera-level, although if possible, capturing species identities if there are sufficient distinguishable characteristics. All identifications are somewhat tentative in that charred remains suggest a particular type that compares well or is a similar match to unique biological categories. All identified specimens must be charred (the well-supported assumption that charred likely represents ancient use). Uncharred specimens are excluded from richness calculations and the minimal volume application unless it is clear they are ancient based on the type and context. Although the SAC approach is described as a method that focuses on the capture of genera richness[24] through limited subsampling, in application it accounts for several biological and cultural categories by interpreting unique human use such as food, fuel or other-type remains in the process. Thus, the method also allows some flexibility in how "richness/variety" is defined in an effort to ensure that the approach captures a meaningful measure of cultural use. In this respect, individual "parts" such as seeds or wood are considered separate human use categories and propel subsampling by being considered separate taxa.

Flotation samples often yield plant remains that are fragmented, degraded, and identifiable only as "comparing favourably" ("cf") to botanical categories of family, genera, species and "part."

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[24] Much of the ecological foundations of the SAC approach refer to "species" richness. The SAC approach is designed to capture "taxonomic" richness because it accounts for genera, hopefully captures species, and definitely distinguishes unique parts. Later in the discussion here, I suggest the term "taxa" that traditionally reflects a system in science for classifying, in our case, biotic things, is expanded to include other categories of analysis. These are remains with unique attributes that enhance understanding of the archaeobotany of a site, "taxa" broadly meaning "new information."

These samples are equally as likely to capture remains that are difficult to classify, not having retained enough morphological characteristics to firmly anchor identification although often their general shape and size is suggestive. Parts are a unique kind of category of analysis. Depending on what parts they are or appear to be, they can add important additional information about the ancient use of plants and the mechanics of use. The recovery of a specific plant part may provide evidence to support the use of that specific part or suggest secondary evidence of the use of other parts of a plant. The presence of charred seeds in a sample from a cooking feature may be interpreted as the use of a particular plant type for food whether for the seed itself or as evidence that other parts of the plant such as the roots or leaves, might have been used. The same plant used for its wood however, has a different interpretative potential, suggesting the use of the wood type for fuel; hence the reason for distinguishing parts and accounting for them as unique information. The categories of "seed" and "wood/charcoal" are interpreted as two distinct use categories ("food" and "fuel" and are considered separately as representing unique identities, not simply a single count of a particular genus or species). On the other hand, some species, such as species of *Pinus*-type (pine), are not counted as separate identities but subsumed under the general category of "pine." For example, *Pinus edulis*-type (pinyon pine) wood, if previously identified in a sample as *Pinus*-type (pine) wood, is considered the same identity in the current configuration of the SAC approach because, the reasoning is we have already captured information about pine (Adams 2004: para. 28; Karen Adams, personal communication, 2008). The distinction of "pine" in calculating diversity (in the case of wood-types) filters information about different pine types, which may or may not have adverse implications for interpretation.

Typically, biological categories (family, genera, species) and cultural distinctions, "part(s)" have been lumped under the general term "taxa" (as in taxonomic richness, or taxonomic diversity). Biological identities also reflect some quality of why and where humans use these categories of plants. As much as anything environmental, their identification serves a purpose of talking about how people interacted with plants. I rely on the awkward category of "genera/species/parts" to reflect the identities the SAC approach hopes to capture in an effort to be clear. The intent is to account for new information or additional inferences. If these distinctions are deemed too arbitrary and subjective, one only needs to look at the term "species" in the ecological literature.

Defined in the dictionary as "a class of things having some common characteristics" in one configuration (Bisset 2000:1006), in species-area research, the term "species" is a word that Mayden (1997) writes encompasses the "saga of the species problem" being understood in at least two-dozen different ways. Scientists continue to argue over what geneticist, Hey (2001:326), suggests are the "extensions" associated with it, stating that "it is as if on one hand we know just what 'species' means, and on the other hand, we have no idea what it means." We use the term in the same notional ways as we do the term "diversity." It comes across in much of the literature as an abstract where individual identification is not the focus, but rather the concept of it. In the SAC approach, taxa/species/genera identities include various categories of analysis some of which have value as interpretative categories and potential cultural associations.

Final considerations: what is a "representative" sampling using the SAC approach?

To borrow Edward O. Wilson's (2001) words, the flaws in this chapter lie in the "oversimplication and incompleteness" of my discussion, reducing complex ecological, statistical and mathematical concepts to some basic ideas which, as Wilson states, "are endemic" to the early (and, I would say, later) efforts to understand and explain diversity patterns in ecology. Regardless of my errors here and I presume, based on the subject, there are a few, ecologists are still arguing over this apparently less than perfect diversity "law." Indeed, the language of ecology perhaps needs to be revisited, as I have attempted to do, to illuminate the challenges we are accepting as applicable to archaeology if we decide to go this route. Other than limiting sampling, the question should be what does sampling to redundancy and the SAC approach actually reflect? Both are built on assumptions, some that we are aware, others have not been fully explored. Species-area assumptions have been described more fully in later ecological literature and we have not kept pace. We have presumed a representative sample using the approach, and we have presumed redundancy of sampling effort confirmed by the asymptotic line. Two basic assertions are made:

1) The SAC approach or any approach that uses asymptote to mean sampling to redundancy will cut off redundant subsampling effort; and,
2) That volume and richness vary in relationship to each other and can be standardized without adverse effects on richness measures.

Any sampling to redundancy process assumes a valid estimation of a population through limited sampling. The SAC approach, as does sampling to redundancy in any form, implicitly claims to predict or estimate richness (there is some room for less than a total count of "richness") because species-area and minimal area concepts tell us it will. However, species curves and species accumulation/effort curves *estimate* richness through complicated statistical and mathematic reasoning. Hayek and Buzas (2010:259-260) observe of these curves that,

> Because we never actually have a chance to obtain or observe some of the species in the target area, for reasons of scarcity and behavioral characteristics, among others, our sample estimate is almost always low... Species-richness estimators have been developed to provide a larger richness value that is more representative of the total number of species in the area than the observations themselves show. However at this time it appears that no one estimate is clearly the best, or most usable, for natural

> population work. In addition, although a few estimates…have desirable properties, no one has shown that any one of these estimators actually comes close to providing a value with any consistency.

As these researchers acknowledge and I have attempted to show, species accumulations tell us about sampling effort, not necessarily estimations of diversity or richness and thus are likely underestimating their measure. Bohrer and Adams (1977:40) cautioned early on that some archaeobotanical remains are missed because specimens are scattered in unknown ways. Spatial distributions either have no discernable pattern or are aggregated or clumped and create problems for assessing any kind of regularity. In response, many argue that archaeobotanical analysis should focus attention only on common species; outliers (rare species) are problematic for a number of reasons (Lepofsky and Lertzman 2005:184). These include the expectation that rare taxa will be missed, rare taxa are too costly to make the focus of analysis and rare taxa lack the potential to shed light on patterning. There is no easy fit for outliers. However, sampling to redundancy and the SAC approach should capture "rare." This is so if our samples are large enough, the normal probability distribution applies and there is consistency with a common to rare spatial accumulation pattern. Additionally, Jones, M. (1991:58) also cautions that, "our target quanta need to relate to research objectives rather than single contexts." However, the patterning of data collected from single samples, subsampled fractions and individual deposits form the foundation of any research conclusions. Van der Veen (2007:986) provides an example of the problem in her description of "the daily preparation and consumption of food," activities that hold important anthropological qualities: timing, gender roles, day-to-day routine or celebratory events, group size etc. The individual sample from a food preparation area such as a hearth or firepit is critical for assessing and comparing scales of depositional effects as well as deliberate and accidental human actions, actions that may be universally shared across a site and culturally significant. The quality of "rare," as in what constitutes a rare event, can only be firmly anchored as such if the individual deposit is assessed for *rare* (the other side of the "common" coin), rare seemingly occurring at the tail end of the accumulation process.

Beyond defining what the term "representative" means for archaeobotanical deposits, samples, and subsamples, flotation volumes are subjectively selected measures of area, defined prior to going in to the field, collected when appropriate features come to light under excavation. These subjective decisions become the excavated volume of unknown quality (ancient-historical-modern-mixed or some combination). The species richness in these excavated volumes represents recovered and recaptured remains from a processed space. The data represent an unknown original depositional richness and anthropological content that does not distinguish species richness as a number but as a cultural quality. Caution is obviously required when interpreting meaning to richness data under these conditions. Hubbard and Clapham (1992:118) acknowledge that the “precise composition of an archaeobotanical sample has no relationship to the economy from which it is derived other than establishing that certain plants were present,” but the order of observations are assumed to represent the capture of common species trending to rare. Indeed, the significance of remains, while perhaps not ecologically or economically important, may have technological significance (118), which reintroduces fragmentation to the mix and calls into question the idea of “order,” as in the plotted order of identifications we see in accumulation curves, understood as “species-area” curves. If the order of subsampling effort does indeed capture the typical species-area curve pattern of a sharply rising line that tapers off as we reach maximum diversity and this patterning reflects a real measure of taxonomic richness, we have accomplished a true accounting of the *capturable* and *identifiable* taxa from a single screen in a flotation sample. How this plays out in simulation and using Sand Canyon Pueblo archaeobotanical data shed light on this ecologically supported, but problematic, light fraction method.

Chapter summary

Archaeobotany shares with ecological research the goals of finding ways to measure, understand, and estimate botanical richness. Based on several key assumptions originating in ecological theory, the SAC approach serves as a tool for estimating, accounting for botanical remains, and managing sampling effort. “Species” are found in archaeological deposits because someone discarded or lost them there, an interpretative aspect that is also managed using the SAC approach. If the ecological species-area patterning holds true for archaeobotanical samples (*common grading to rare species capture*), sampling effort will be effective and reach an identifiable and meaningful plateau related to richness content. However, the SAC approach uses patterning to tell us if additional sampling is required or redundant, a pattern that more recent SAR research tells us is problematic particularly when assuming accumulation plots are similar to “area” plots. In the next chapter, the assumptions of the SAC approach are tested in simulation to quantify how well the method works for estimating the contents of a light fraction screen and potential impacts on deposit content.

Chapter 4 Species-area curve approach in simulation

Chapter overview

The species-area curve approach (SAC) is a sampling to redundancy strategy (STR) founded on the assumptions of species-area curves. These include the plotting of curves to estimate species "asymptote" or the assessment of the number of different species in bounded ecological habitat (Mueller-Dombois and Ellenberg 1974). The SAC approach has been used to identify archaeobotanical "asymptote" for light fraction particle sizes through managed subsample volumes. To test the assertions of the approach I created experimental "firepits" and introduced a known quantity and quality of charred seeds ("exotics") to observe the effects of the approach in simulation. Two archaeobotanical sampling strategies are evaluated: the effectiveness of limiting analysis to a single one-litre flotation volume, and the use of the SAC subsampling approach for limiting the analysis of the smallest particles of light fraction in a one-litre sample. Results are confirmed through statistical tests conducted by Dr. Philip Molloy, private consultant.

Background

Measuring the effects of a sampling strategy using archaeobotanical remains is difficult, requiring ways to assess what counts, what does not count, how to quantify and qualify results and the appropriateness of the analysis when actual archaeobotanical content is unknown. The experimental study aims to provide a less constrained dataset and a known population of deliberately charred modern material as proxies for archaeobotanical remains.

The species-area curve (SAC) approach is formulated to capture the botanical richness of specific light fraction portions through limited subsampling rather than full analysis applied to the smallest and most time consuming of particle sizes, the 1.4 mm, .71 mm, and .25 mm portions. It is founded on the typical patterning of species-area curves modeled in ecological diversity studies. Species-area curves are thought to identify species asymptote or, the richness of particular habitats in nature, capturing "diversity" through the identification of a "minimal area" of analysis─the overall sample size. Minimal areas represent the smallest area from which an "adequately" representative subset of a species population is observed (Mueller-Dombois and Ellenberg 1974:47). Minimal areas vary for different habitats and are calculated through the process of sampling larger and larger areas to the point where no new species are observed over multiple samples. Sampling efforts after this point are presumed to be redundant. As detailed in chapter three, the plotting of species-area curves identifies the extent of area required to reach this point (Figure 3.1, p. 61). The identification of minimal sample area, redundancy and asymptote are functionally one and the same, all providing information about the richness of a sampling situation through the identification of a stopping point of analysis; a point at which further sampling effort will seemingly yield no new information.

The SAC approach borrows from this ecological strategy in an effort to capture an "archaeobotanical asymptote." I co-opt the term, asymptote, to reflect the point of maximum recoverable exotic richness for experimental flotation samples. The analytical goals of the SAC approach include: managing the debris of flotation samples, limiting excessive analytical time and capturing representative ancient botanical data (Adams 1993; 2004). This is usually thought of as achieving "representative" samples, but common sense dictates that "adequate" samples may be all we can hope for. This designation is likely dictated by budgets and research questions and the bulk of material requiring analysis. Because of costs in time and effort, rarely are bounded deposits completely analyzed to provide a baseline of data. By identifying a minimal volume for light fraction portions, the SAC strategy is thought to estimate and thus, suggest the minimal amount of volume and time required for the capture of asymptote in the most analytically time-consuming portions of light fraction—the 1.4 mm, .71 mm and .25 mm particle sizes. The SAC minimal volume (effectively an increase in "plot"/subsample size) is thought to be responsive to the diversity of a light fraction sample and flexible enough that it can be standardized for particular particle-sized remains excavated from most archaeobotanical settings, specifically sites in the arid American Southwest. The question is, does the approach achieve these ends?

My experimental study is designed to shed light on the assumptions of the SAC approach, the most fundamental of which is that all things are reasonably equal. Because the SAC minimal volume is flexible, the context, processing, analytical effort, and relationship between species and volume are deemed to have some degree of universality. Basic assumptions of the approach can be broken down into the following categories:

1) <u>The assumption of curves</u>: the SAC approach presumes that curves generated by plotting species observations over "area"/volume sampled can provide a method to estimate asymptote for archaeobotanical or other archaeological artifacts because "our" curves are thought to mimic the patterning so typical of ecological species-area and species accumulation curves which seemingly estimate species asymptote also.
2) <u>The assumption of a richness-volume relationship</u>: the SAC approach assumes that the richness of a light fraction portion will impose limits on subsampling volume and thus subsampling effort. In other words, that the diversity of a sample, like the diversity of an ecological habitat, will propel sampling effort

because increased diversity means increased area/volume required to capture it. *Why?* Because a sampling to redundancy approach such as the SAC is thought to be more or less equivalent to the ecological law of species-area relationships.[25] Furthermore,

3) The assumption of volume as a meaningful "area:" the SAC approach presumes that a standardized volume (a "minimal volume") can be used to capture redundancy of sampling effort because it also captures a representative subset of a light fraction "population" based on the minimal area concept (Mueller-Dombois and Ellenberg 1974). Volume and species content are thought to co-vary and thus, will be predictable under the influence of how diverse the sample is.
4) The assumption of asymptote/redundancy of sampling effort: the SAC approach presumes that species asymptote can be identified through limited subsampling rather than full analysis for the same reasons as above. A further benefit to the asymptote assumption is that it also identifies a point of redundant sampling effort and thus limits analytical time.
5) The assumption of patterning as reflecting common species grading to rare species capture*:* The SAC approach relies on the consistent patterning of ecological curves demonstrated by a sharply rising line that tapers off or flattens when species data are plotted and taper off as no new species are observed. The patterning is purported to demonstrate that "initially many species are found as larger areas are sampled and a plot of accumulated number of species against

[25] There is little doubt that species diversity increases with area sampled in nature mirroring what Arrhenius (1921:95) stated as, "the well-known and obvious fact, that the larger the area taken the greater the number of species." The SAC approach relies on this ecological reality and the common/rare accumulation patterning apparently demonstrated in species-area and accumulation curves that suggest a diversity number. Increased diversity will require more sampling effort. Critical analysis of these statements suggest that Arrhenius' comment reflects the opposite: more sampling leads to increased diversity *capture* prompting the question, does increased sampling lead to more species observed or, does diversity drive the increased sampling of a habitat and is there a difference? This could be the difference between sampling a well-bounded space vs. mistakenly sampling a new space or a boundary between two different habitats, or simply but discouragingly, reflect sampling error. It can also reflect the types of species accounted for and their tendencies for abundance/density, ignoring some species (insects, birds, for example) and focusing on others. Although rigorously debated, the species-area and species accumulation patterns modeled by curves in ecology have, up until recently, been universally accepted as true and reasonable estimations of natural populations. Species-area is also defined as the relationship between the area of land and the number of species it supports (larger areas support more species than smaller areas)(Rosenzweig 1999), putting a subtle but different slant on the idea. Based on the somewhat optimistic mathematics and the on-going debates over how to quantify nature, it calls into question how much of diversity data and the concept of "asymptote" is based on sampling effects and what this might mean for any sampling strategy.

> area sampled rises steeply at first and more slowly as the *increasingly rare species* are accounted for (Ugland et al. 2003:888; emphasis added). The point at which the line curves to horizontal, representing the point at which fewer and fewer to no new species are encountered, is considered to indicate species asymptote (and also indicates the capture of the rare species).

To test the effectiveness of the SAC method and evaluate these assumptions, I designed three experiments and created simulated "firepits" with a known quality and quantity of charred material. I introduced charred seeds ("introduced exotics") as proxies for the archaeobotanical remains that are often recovered in flotation samples. The experiments model and quantify the recapture of exotics to illustrate the effectiveness of the approach. As the SAC approach may impose effects on richness estimates for real archaeobotanical samples, effects that are likely always to be unclear, the experimental firepit analysis provides known "populations" of richness that can be measured. The experiments do not test for a "species-area relationship," or more accurately, a relationship of "species" and "volumes" for flotation samples as standard for archaeobotany. Two strategies that limit analysis at the sample-level and the subsample-level are demonstrated: 1) the use of the single one-litre flotation volume as adequate to capture a representative sample of the botanical richness of a deposit; and, 2) the application of the SAC approach to limit the subsampling of light fraction as an effective method for the estimation and capture of botanical content of light fraction portions. Two fundamental questions are of interest in SAC subsampling: are we sampling *enough volume* in terms of litres analyzed, and are we sampling *deep enough* in terms of minimal volumes to acquire representative samples using these strategies? In deference to Pearsall's (2000:216) recommendations regarding statistical analysis in paleoethnobotany, I sought expertise from Dr. Philip Molloy, a statistical consultant to test the results for statistical significance.

Addressing sampling unknowns: the SAC approach in an experimental setting

The most obvious "unknowns" imposed on the richness content of real archaeobotanical samples are introduced by the nature of archaeological deposits, the scale of taphonomic processes and laboratory methods of flotation, screening (sorting into geologic screens), subsampling and microscopic analysis. The creation of simulated deposits with a known number and richness of taxa, controls for some of these effects. The simulated deposits were created to be reasonably authentic and low in overall volume (five litres in total volume for each of six "deposits"/firepits). Because the SAC approach constrains subsampling at particular particle sizes (1.4 mm, .71 mm, and .25 mm), the method could underestimate the botanical contents of these screens, which in turn underestimates the richness of a sample. In this respect the method may or may not significantly influence how effective a single one-litre flotation sample captures the richness of a deposit.

I identified four basic questions for my experimental data:

1) Does the SAC approach capture the introduced botanical content of a simulated sample?
2) Is the flexible minimal volume sufficient, and if not, does increasing the minimal volume produce better results?
3) If increasing minimal area imposes an unreasonable burden on sampling effort, can increasing the number of samples analyzed per "deposit" resolve any underestimations? The effect would be either analyzing more samples versus analyzing more subsamples for better results.
4) Does species richness drive subsampling effort? In effect, does the flexibility of the minimal volumes standardized in the SAC approach respond to the diversity of a light fraction portion?

As previously described, the SAC approach is a method of capturing the richness of a portion of light fraction through a standardized subsample volume of .9 ml or .3 ml depending on the particle size, and a flexible minimal volume of three consecutive unproductive subsamples for each size grade[26] until no new species are identified (Adams 2004). Conforming to SAC standards, all samples in this study yielded over 50 ml of total light fraction, the triggering point for the SAC application.

Scope of analysis

The null hypothesis posed for this study is that the SAC approach imposes no adverse effects on richness measures through limited subsampling for individual light fraction screens or for one-litre samples. The patterns of accumulation will mimic that of ecological species-area accumulations and indicate a point of redundancy of sampling effort. The patterning of recovery will reflect the capture of common species in the initial sampling stages and taper off as no new species are observed indicating species asymptote, maximum species richness *and* the capture of rare species. The alternative hypothesis is that the SAC approach negatively impacts richness measures and underestimates the botanical contents of light fraction portions. This in turn will underestimate the botanical content in samples and deposits and thus constrain interpretation of the plant record. If no significant difference is detected between full sampling (a "complete analysis" abbreviated as "CA"

[26] Unproductive subsamples are those subsamples that contain no new charred exotics. Using the SAC approach, three unproductive subsamples trigger the SAC stopping point and are thought to indicate the minimal volume required to capture a light fraction portion-specific botanical asymptote and the point of redundant sampling effort.

reflecting a 100 per cent survey) and limited sampling using the SAC approach, it can then be argued that underlying mechanisms responsible for archaeobotanical richness patterning in real samples is not due to the method but reflects other limiting factors and unknowns.

Methods and materials

Six simulated reasonably authentic "archaeobotanically rich" low-volume firepits (five litres in total volume per simulation) were created. A variety and richness of seeds ("exotics") were introduced that could be recovered using standardized methods of flotation, laboratory screening and microscopic analysis using the SAC subsampling approach. All specimens were charred to mimic archaeological firepit content. Three experiments simulate flotation analysis and SAC subsampling in a simulated bounded deposit type.

Methods

Experiment 1/Firepits 1-4: SAC subsampling for known introduced content

This experiment tests the effectiveness of SAC subsampling where the content of the samples is known but SAC subsampling to the "asymptote" point limits exotic capture. The data are compared with known introduced content although the distribution of the exotics remains unknown. Experiment 1 is the closest simulation to real archaeobotanical sampling where the full complement of ancient remains is unknown and we presume the SAC approach captures a representative subset of the content. I created four simulated firepits (1-4) in this experiment. Each firepit contained five litres of fuel wood charcoal, sediment and a known quantity and quality of charred exotics, the equivalent of five one-litre samples. One-litre samples were collected from each "firepit" and subjected to standardized flotation processing, light fraction screening, and microscopic analysis. SAC subsampling was imposed following Adams (2004). At the point at which no new species were observed over three consecutive subsamples, subsampling was discontinued and "species asymptote" for the individual light fraction screens was presumed.

Experiment 2/Firepit 5: SAC results for known content, known distribution

I designed "firepit 5" to test the effectiveness of the SAC approach through complete analysis (a "CA" approach) to estimate the actual content of five simulated flotation samples. Firepit 5 was assembled in the same manner as firepits 1-4 and contained five litres of simulated archaeobotanical material (charcoal and sediment content) and a known quantity of charred exotics. As before, five one-litre samples were collected, subject to flotation, light fraction screening, and microscopic analysis as in the first experiment. Data was recorded through the subsampling process but subsampling continued after SAC asymptote was indicated. In this way the full exotic content of the samples are known. The patterning of recovery allows for assessments of the species asymptote assumption and takes into account the effects of flotation on exotic recoverability.

Experiment 3/Firepit 6: SAC subsampling with increased diversity, known content, known distribution

Firepit 6 was designed to test the impacts of increased abundance and richness of exotic content on SAC results. The presumed effects of flotation and uneven distribution of material thought to bias recovery of exotic content are accounted for through complete analysis of all the material in this "firepit." The concern for this experiment is the flotation effect: how flotation processing might bias exotic recovery and underestimate the effectiveness of SAC subsampling. Because each size grade of exotics was introduced in the same quantity we can rule out common and rare "species" as a reason, if needed, for differences in exotic recovery. I also wanted to test the effects of increased "diversity," more exotics in the subsampled portions and decreased "firepit" content. In order to create a reasonably even distribution, firepit 6 is actually five separate one-litre flotation samples. The materials were not mixed as in the previous experiments but the data are combined. Firepit 6 experiment is a dataset simulation. One dataset accounts for increased "abundance" (the number of specimens for each of 30 exotics was increased from 1 to 5 specimens each). The other dataset accounts for increased "abundance" (the extra specimens as dataset 1) and increased "richness," an additional nine new unique exotics. I presumed that a flotation effect would impact the smallest exotics, particularly the .25 mm specimens, to the point of no recovery at all. This experiment tests both the SAC approach under increased diversity but also the impact of flotation on results.

The SAC approach relies on the patterning of observations of new species to inform common or rare assessments of plant materials. Because all class sizes of exotics were introduced in the same quantities we must assume that either the SAC approach or flotation processing biases exotic recapture. The entire content of firepit 6 samples was evaluated and recorded, the statistical analysis of firepit 6 is split as two datasets: dataset 1 consists of an accounting of increased numbers of exotics ("abundance") and dataset 2 consists of an accounting of increased variety and increased specimen counts ("richness").

Materials

Simulated firepit content

My experimental firepits were created from modern sediments consisting of earth, sand, rock and uncharred plant materials such as roots and twigs collected from six inches below a natural undisturbed surface located in a dry forested habitat of Ponderosa pine (*Pinus ponderosa*) and

Douglas-fir (*Pseudotsuga menziesii*) in the North Okanagan, British Columbia. The ecology and plant covered is consistent with arid pine and grassland habitat typical of southwestern Colorado. The locale had abundant serviceberry (*Amelanchier alnifolia*), big sagebrush (*Artemisia tridentata*), arrowleaf balsamroot (*Balsamorhiza sagittata*) and a variety of grasses, most notably bluebunch wheatgrass (*Agropyron spicatum*) on site. The excavated sediments are similar to typical sediments and matrix found in flotation samples. I collected seventy litres in total and mixed these indoors on a tarp to assure a reasonably homogeneous composition. I pinch-sampled a control sample of one-litre, dry screened it through the standard geologic light fraction screens (4.75 mm, 2.8 mm, 1.4 mm, .71 mm, and .25 mm) and evaluated all the content under the microscope to assess native seed content (Table A.1, Appendix A). The SAC approach was not applied. Particles less than .25 mm (the catchpan screen) were briefly scanned.

I created simulated firepits using the mixed sediments and a selection of wood and tinder-type materials I collected and charred. The materials I selected consist of Okanagan native hard and soft woods and tinder-type materials (cones and needles). I added the charcoal and "tinder" in standardized amount to all the samples until a one-litre flotation sample was created (Table 4.1).

Table 4.1 Experimental one-litre flotation samples: charcoal, tinder and sediment content

Material	**Scientific name**	**Common name**	**Volume (ml)**
Sediment/matrix mix	*Natural, undisturbed sediment and matrix*	-	650
Fuel wood			
(hardwood charcoal)	*Pinus ponderosa*	Ponderosa pine	100
(softwood charcoal)	*Populus balsamifera ssp. Trichocarpa P. trichocarpa*	Black cottonwood	50
Shrubby Fuel/Tinder			
(charred wood, twigs, leaves)	*Artemisia tridentata*	Big sagebrush	50
	Amelanchier alnifolia	Saskatoon	50
Tinder			
(twigs, bark)	*Pinus ponderosa*	Ponderosa pine	50
(needles, cone scales)	*Pinus ponderosa*	Ponderosa pine	50
Total sample volume			**1000**

For experiment 1 and 2, five one-litre samples were mixed together for each simulated firepit (Firepits 1-5). For experiment 3 (Firepit 6), the samples were not mixed together but used to simulate a more even distribution and higher diversity of material based on the content of "exotic" seeds added. The samples were numbered according to the order of collection after mixing for experiments 1 and 2 and processed individually by water flotation. Samples for experiment 3 were individually mixed and floated separately. The light fraction was screened as per Adams (2004) and the content scanned using a Meiji Techno EMZ-8TRD microscope at 7X – 45X magnification.

Exotic seed content

I selected exotics to be size appropriate to the individual light fraction screens and pre-screened each type to ensure good results. Introduced seed content consisted of various hardy seeds, fruits and caryopses purchased locally from garden centers, grocery stores and through seed companies (Table 4.2).

Table 4.2 Introduced exotics by experiment.

Scientific name	**Common name and package description**	**Approx. size (mm)**
Basic exotic content (Firepits 1-6)		
Alcea L.	hollyhock (“old fashioned giant single mixed”)	2.8
Apium graveolens L.	wild celery	.71
Borago officinalis L.	borage (“heirloom borage”)	2.8
Chenopodium quinoa Willd.	quinoa (“black”)	1.4
Cucurbita L.	squash (“table queen royal acorn”)	4.75
Erogrostis tef (Zuccagni) Trotter	teff (“teff grain”)	.25
Fagopyrum esculentum Moench.	buckwheat	2.8
Helianthus annuus L.	common sunflower	4.75
Lactuca sativa L.	garden lettuce (“buttercrunch”)	1.4
Lagenaria siceraria (Molina) Standl.	bottle gourd (“birdhouse”)	4.75
Lathyrus latifolius L.	perennial pea (“everlasting pea”)	2.8
Lobelia L.	lobelia (“lobelia color cascade”)	.25
Melissa officinalis L.	common balm (“lemon balm”)	.71
Mentha x *piperita* L. (pro sp.) [aquatica x spicata]	mint (“peppermint”)	.25
Nicotiana L.	tobacco (“nicotiana daylight sensation mixed”)	.25
Ocimum basilicum L.	sweet basil	.71
Origanum vulgare L.	oregano	.25
Papaver L.	poppy	.71
Phaseolus vulgaris L.	common bean (“dwarf bean Borlotto”)	4.75
Physalis L.	groundcherry (“tomatillo”)	1.4
Piper nigrum L.	black pepper (whole black peppercorns, bulk)	2.8
Portulaca L.	purslane (“portulaca double mix”)	.25
Rosmarinus officinalis L.	rosemary	1.4
Salvia hispanica L.	chia	.71
Secale cereale L.	cereale rye (“Fall rye”)	2.8
Sinapis alba L.	white mustard (“yellow mustard”)	1.4
Trifolium repens L.	white clover	.71
Trigonella foenum-graecum L.	sicklefruit fenugreek	1.4
Tropaeolum L.	nasturtium (“dwarf jewel”)	4.75
Zea mays L.	maize/corn (“sweet corn bodacious”)	4.75
Additional exotic content (Firepit 6 only)		
Aquilegia L.	columbine (“McKana giants mixed”)	.71
Eleocharis palustris (L.) Roem. & Schult.	common spikerush (“creeping spikerush”)	.25
Gypsophila elegans M. Bieb.	showy baby’s-breath	.71
Heuchera sanguinea Engelm.	coralbells	.25
Linum L.	flax	1.4
Phacelia heterophylla Pursh.	varileaf phacelia (“white scorpionplant”)	.71
Phlox drummondii Hook.	annual phlox	.71
Polemonium L.	Jacob’s-ladder (“blue pearl”)	.71
Raphanus sativus L.	cultivated radish (“crimson giant”)	1.4

I charred the seeds in aluminum foil on a barbeque (low heat) as I did with the wood and tinder. I saw no discernable shrinkage after charring. In addition, I soaked a selection of each specimen type in water after charring for 24 hours to ensure that enough morphological characteristics were retained after immersion in water. Those varieties that degraded were discarded. Of the pool of varieties, I chose six exotic types for each of the light fraction particle sizes. Additional varietals of approximately 1.4, .71 mm, and .25 mm size were also selected for firepit 6 testing. Of these most met the criterion of being non-native to the North Okanagan where the sediments were collected to assure only exotic content was counted. Exotics such as *Lathyrus latifolius* (perennial pea), *Portulaca* sp. (purslane), and *Trifolium repens* (white clover) that may have been present naturally in the sediments were deemed distinguishable from native seeds by virtue of charring. The exotic content of the firepits varied to test the effectiveness of the SAC approach under different conditions.

Specimen number and "richness" counts

The distribution of exotics aims to reasonably assure recovery in the tested geologic screens based on the size of the specimens. One appropriately sized specimen of the thirty exotics (n = 30) was added to each of the firepits (firepits 1-6). Because of the minute size of some and my concern for loss due to processing, additional varietals and specimen counts were added to firepit 6 (Table 4.3). Five specimens of each of the thirty exotics were added to firepits 1-5, twenty-five of each of thirty-nine exotics was added to the firepit 6 samples (Table 4.3).

Table 4.3 Distribution of introduced exotics by particle size.

Screen/particle size				
4.75 mm	**2.8 mm**	**1.4 mm**	**.71 mm**	**.25 mm**
		Firepit 1-6 exotics (taxa used in all experiments)		
Cucurbita	*Alcea*	*C. quinoa*	*Apium graveolens*	*Erogrostis tef*
Helianthus	*Borago*	*Lactuca sativa*	*Melissa officinalis*	*Lobelia*
Lagenaria siceraria	*F. esculentum*	*Physalis*	*Ocimum basilicum*	*Mentha*
Phaseolus vulgaris	*Lathyrus latifolius*	*R.officinalis*	*Papaver*	*Nicotiana*
Tropaeolum	*Piper nigrum*	*Sinapis alba*	*Salvia hispanica*	*Origanum vulgare*
Zea mays	*Secale cereale*	*T. foenum-graecum*	*Trifolium repens*	*Portulaca*
		Firepit 6 additional exotics (taxa used in experiment 3: evaluating the effects of abundance and richness)		
Not applicable	Not applicable	*Linum*	*Aquilegia*	*Eleocharis palustris*
		Raphanus sativus	*Gypsophila elegans*	*Heuchera sanguinea*
			P. heterophylla	
			Phlox drummondii	
			Polemonium	

Statistical analysis

Statistical tests using the R statistical program (R Core Team 2012) were run on the data. The tests account for the first observation of each unique exotic as would be typically plotted on accumulation curves for the estimation of species asymptote/species richness. Sample data was not randomized and data are plotted as observed. Observations of exotics and non exotic seeds are documented in Tables A.1-A.6 in Appendix A.

Results

Experiment 1: firepits 1-4

One-sample t-tests were run to test for differences between introduced exotic richness (30 unique exotic types) and the number captured using the SAC approach. The SAC approach consistently underestimated the number of exotics for each of the four firepits. The effect is most significant individual samples (mean and range of SAC exotic richness capture: 9.2 [2-19] exotics. One-sample t-test: $t = 22.91$, $df = 19$, one-tailed $p <0.001$). The best results were acquired from firepit 3 sample 5 where 63.3 per cent of exotics are accounted for using the approach (Figure 4.1). A repeat t-test demonstrates that the SAC approach was more effective when data are combined for all firepit content although the approach still significantly underestimated exotic richness (mean and range of SAC

exotic richness combined: 21.75 [16-25]; one-sample t-test: $t = 4.09$, $df = 3$, one-tailed $p = 0.013$). Normality verified by a Shapiro Wilk's test (both $p >0.05$).

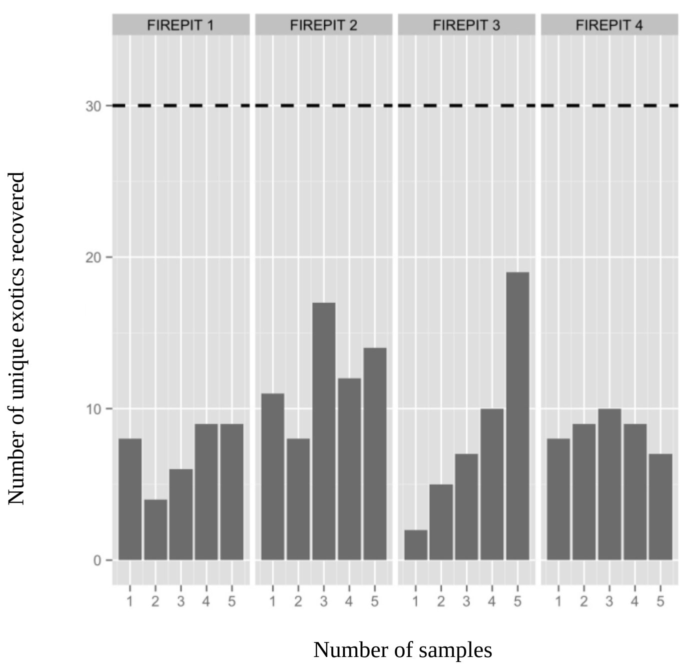


Figure 4.1 Firepits 1-4 sample-based recovery: total number of unique exotics observed in each of five flotation samples using the SAC approach for four simulated firepits. Dashed horizontal line at 30 represents variety of exotics introduced. Results include recovery in all screen sizes. Figure (Molloy), labels adjusted to reflect original data (van Roggen).

The analysis of firepits 1-4 data simulates the capture of exotic taxa and reflects the all too real constraints put on flotation sample analysis for archaeological features. The results show the consistency of poor SAC results and uneven botanical content in simulation. If only one sample from firepit 3 was selected for analysis such as might occur in real archaeobotanical situations the odds of capturing the most productive sample are 1 in 5. In the worst-case scenario, analysts would inadvertently select sample 1 and presume a deposit with little botanical content. Experiment 1 models the impacts of the SAC approach on introduced exotic counts between samples and "firepits" but do not factor in flotation and analytical effects on exotic capture and content. Experiment 2 accounts for potential data loss that might result from these biases.

Experiment 2: firepit 5

A paired t-test was used to test for significant differences between SAC results and complete analysis (CA) or 100 per cent survey of sample content. At least one specimen of all 30 exotics introduced to firepit 5 was identified when the data from all five samples were combined. The results were significantly poorer when samples were considered separately (Figure 4.2).

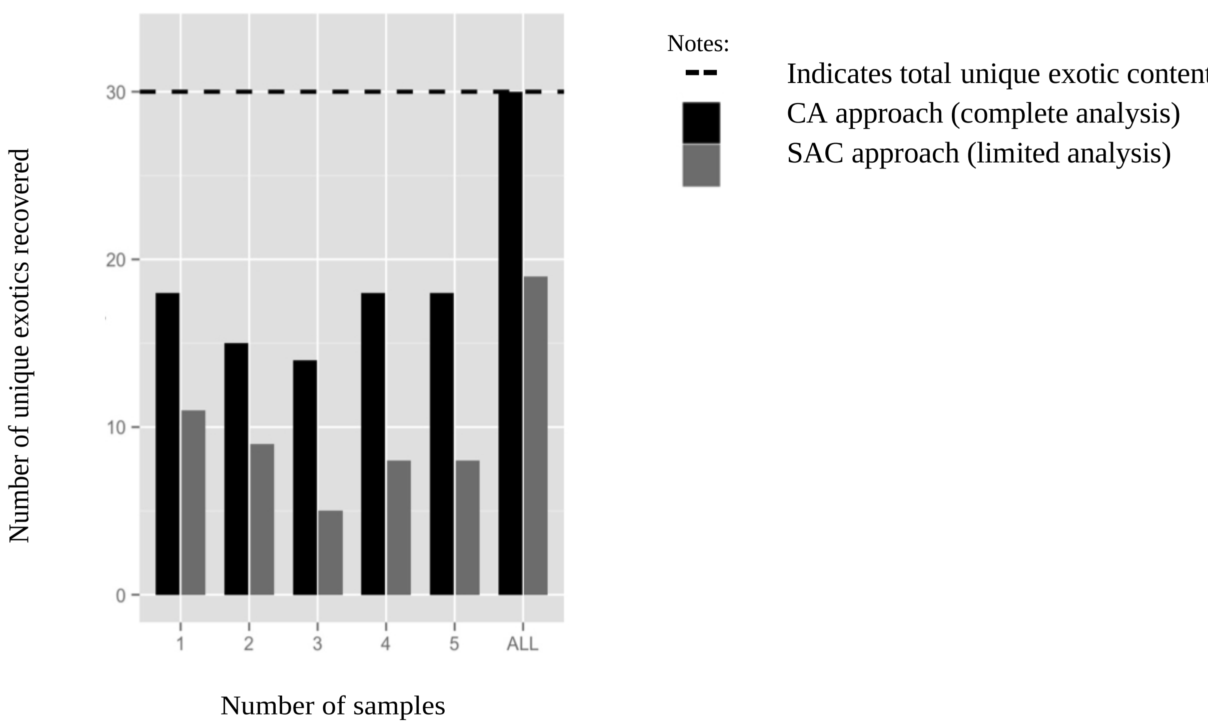


Figure 4.2 Firepit 5 results: limited subsampling imposed by SAC approach compared with complete analysis of five one-litre samples. Grey bars indicate the number of unique exotics observed when applying SAC subsampling. Black bars indicate the number observed when the entire sample was completely analyzed (CA approach). "ALL" column presents cumulative totals for both approaches. Both results include recovery in screen sizes 4.75 and 2.8 mm. Figure (Molloy), labels adjusted to reflect original data (van Roggen).

The SAC minimal volume indicated asymptote and redundancy of sampling effort at 63.3 per cent recovery overall, or 19 of 30 exotics (Figure 4.2, "ALL" column). The mean number and range of exotic capture for complete analysis (CA) = 16.6 [14-18]; mean number and range of exotic capture for the SAC approach = 8.2 [5-11]; paired t-test: $t = -10.3$, $df = 4$, $p < 0.001$. The assumption of normality was verified using a Shapiro-Wilk's test ($p > 0.05$).

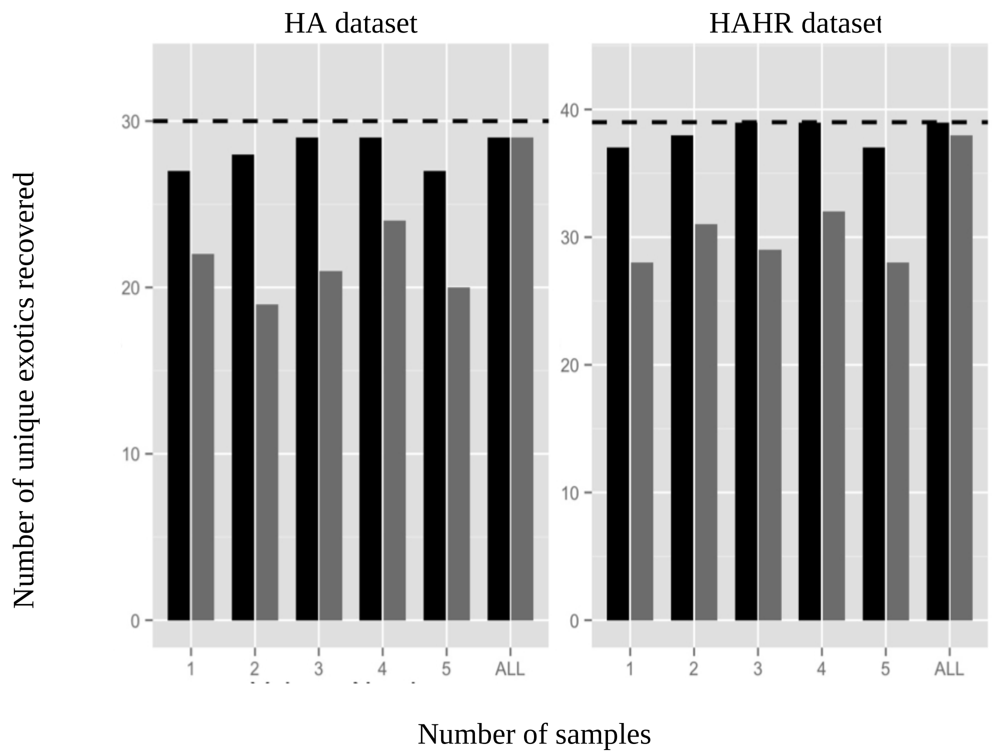
The SAC approach significantly underestimated exotic richness in comparison to a known standard (the CA data) over five one-litre samples. Even if the most productive SAC sample (sample 1) is selected for analysis as might occur in archaeobotanical sampling situations, the SAC approach as it is currently configured underestimates known richness of the sample and underestimates actual firepit content by more than half.

Experiment 3: firepit 6—two datasets

A repeated-measures two-way analysis of variance (ANOVA) was used for the two datasets created for this experiment. One dataset accounts for introduced exotic abundance (additional specimens), the other accounts for exotic richness using both the identified SAC asymptote and data collected through complete analysis (CA) of the samples. The discrepancy between the CA and SAC richness counts and, thus, estimates of total richness, was consistent across the datasets as indicated by the non-significant ANOVA *Experiment*Approach* interaction term. Model assumptions were confirmed following Zuur et al. (2007).

The firepit 6 simulation shows that the SAC approach biases exotic recovery but exotic diversity and richness have a positive effect on SAC results although only when all sample data are combined for a "deposit" total (Figure 4.3, p. 88). The experiment confirms that "diversity" can propel some additional subsampling. However, the number of exotic varieties observed at the sample level is still underestimated. When the results were combined increased diversity of exotics had a similar effect at the "firepit" level as that of the lower diversity of firepit 5. The result, odds are better for capturing more unique exotics, but overall diversity has little effect on "deposit" content. The effects of abundance and richness can be seen clearly when firepits 5 and 6 data are compared as in Figure 4.4 (p. 89).

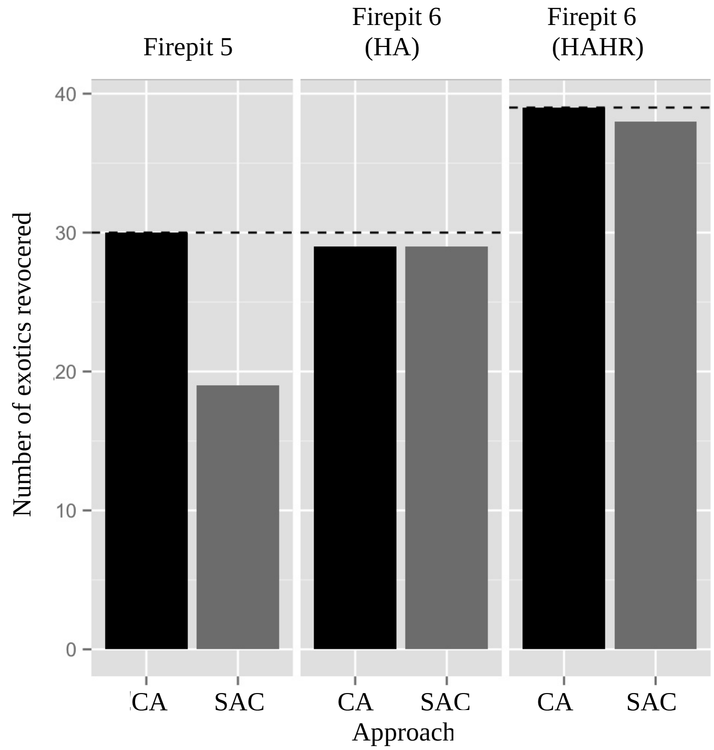
The objective of experiment 3 was to model how the SAC approach responds to increased numbers and varieties of exotics and how richness and diversity influences standardized SAC flexible minimal volumes. Not unexpectedly, firepit 6 results (HA) suggest that abundance is a mitigating factor in how well the SAC approach performs on individual samples by increasing the likelihood that additional variety will be accounted for. The surprise is the similarity in results under lower diversity.



Notes:

Indicates total introduced exotic content (HA = 30 unique exotics; HAHR = 39 unique exotics)
CA analysis (complete analysis)
SAC approach (limited analysis)

Figure 4.3 Firepit 6 data: results of complete analysis vs. SAC approach subsampling. Grey bars indicate the number of unique exotics observed when applying the standardized SAC approach. Black bars indicate the number of unique exotics observed when the entire light fraction was completely analyzed. The HA (high abundance) dataset demonstrates the effects of additional abundance. The HAHR (high abundance + high richness) dataset demonstrates the effects additional abundance and additional richness. When data are combined ("ALL" bars) the results show virtually no difference in exotic recovery between the two approaches. Figure (Molloy), labels adjusted to reflect original data (van Roggen).



Notes:

Indicates total introduced exotic content (HA = 30 unique exotics; HAHR = 39 unique exotics)

CA analysis (complete analysis)

SAC approach (limited analysis)

Figure 4.4 Exotic "diversity" comparisons: firepits 5 and 6 datasets (experiment 2 and 3 results), application of SAC approach subsampling compared with exotic capture using complete analysis [CA] of the entire sample pool. The dashed lines at 30 and 39 represent the number of unique exotic taxa introduced. The CA approach suggests a reasonable standard for the SAC results that takes into account potential flotation, screening and analytical effects. Figure (Molloy), labels adjusted to reflect original data (van Roggen).

Discussion

Exotic curves: patterning and interpretative value

In these simulations, the SAC approach significantly biases richness measures except in the most diverse and likely unrealistic experimental samples (firepit 6) but only at the individual sample level. The 100 per cent survey or complete analysis (CA) of firepits 5 and 6 accommodates for the effects of flotation by providing a reasonable standard of recovery from which to compare SAC data. As the tests demonstrate, flotation (and/or analyst error) effects are minimal (Figure 4.4). Even if minimal volumes are increased, only with full analysis or pooled results can the data be represented based on these simulations. This effect is modeled in plots of firepit 5 and firepit 6 accumulation curves (Figures 4.5 and 4.6).

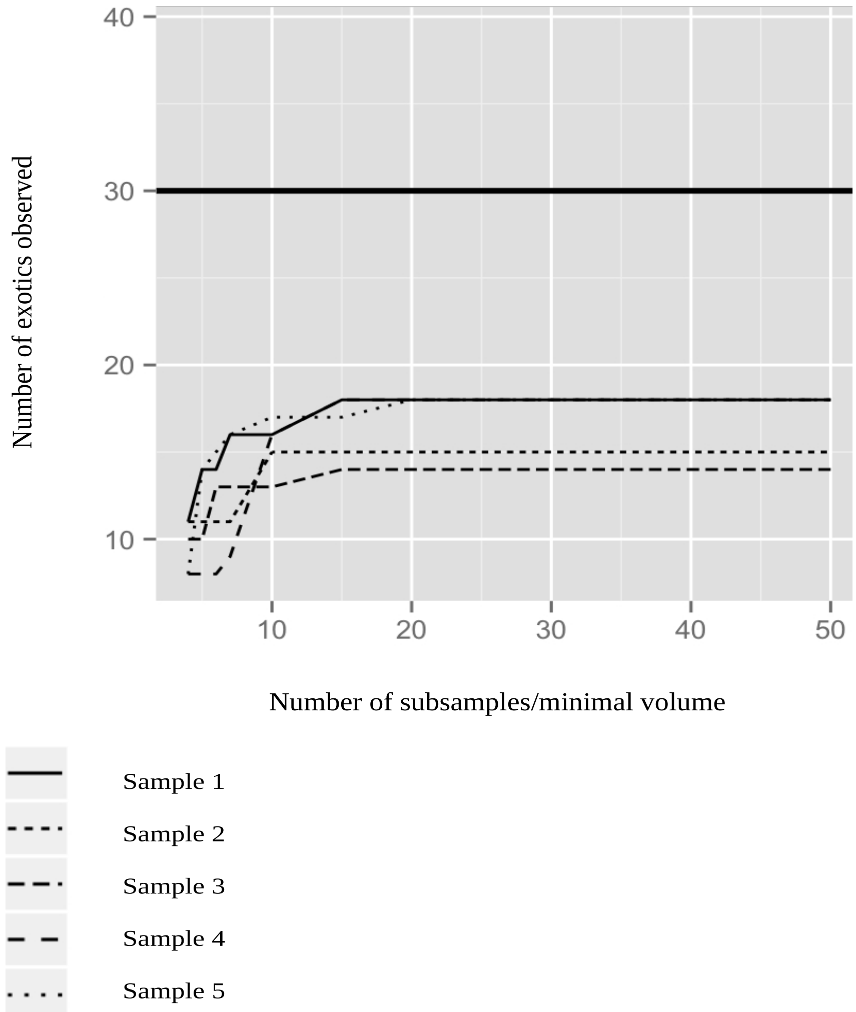


Figure 4.5 Firepit 5 accumulation curves. The curve indicates asymptote at 15 subsamples requiring the minimal volume to be increased to five subsamples, or alternatively 15 subsamples to achieve less than 50 per cent of the content of the combined smallest light fraction screens (1.4 mm, .71 mm and .25 mm) in these simulations. Each sample dataset is shown separately as a different line style. The thick horizontal line at 30 indicates the actual number of exotics added. Figure (Molloy), labels adjusted to reflect original data (van Roggen).

Figures 4.5 and 4.6 (p. 91) show how curves generated through limited subsampling curtail sample and deposit content. Relying on the SAC approach through the plotting of curves and assuming asymptote reflects redundancy of sampling effort reinforces the notion that representative samples are possible using species-area curves. In the Figure 4.5 and 4.6 plots, we would incorrectly assume that minimal volumes of 15 subsamples would result in representative data without knowing the actual content. The rapidly rising line that tapers off so typically seen in ecological species-area and species-accumulation curves is not consistent for simulated samples. In two cases (Figure 4.6), the stopping point had to be increased to 50 additional subsamples to achieve asymptote (sample 4, firepit 6, both HA and HAHR datasets) and these samples contained the richest and most abundant collection of exotics.

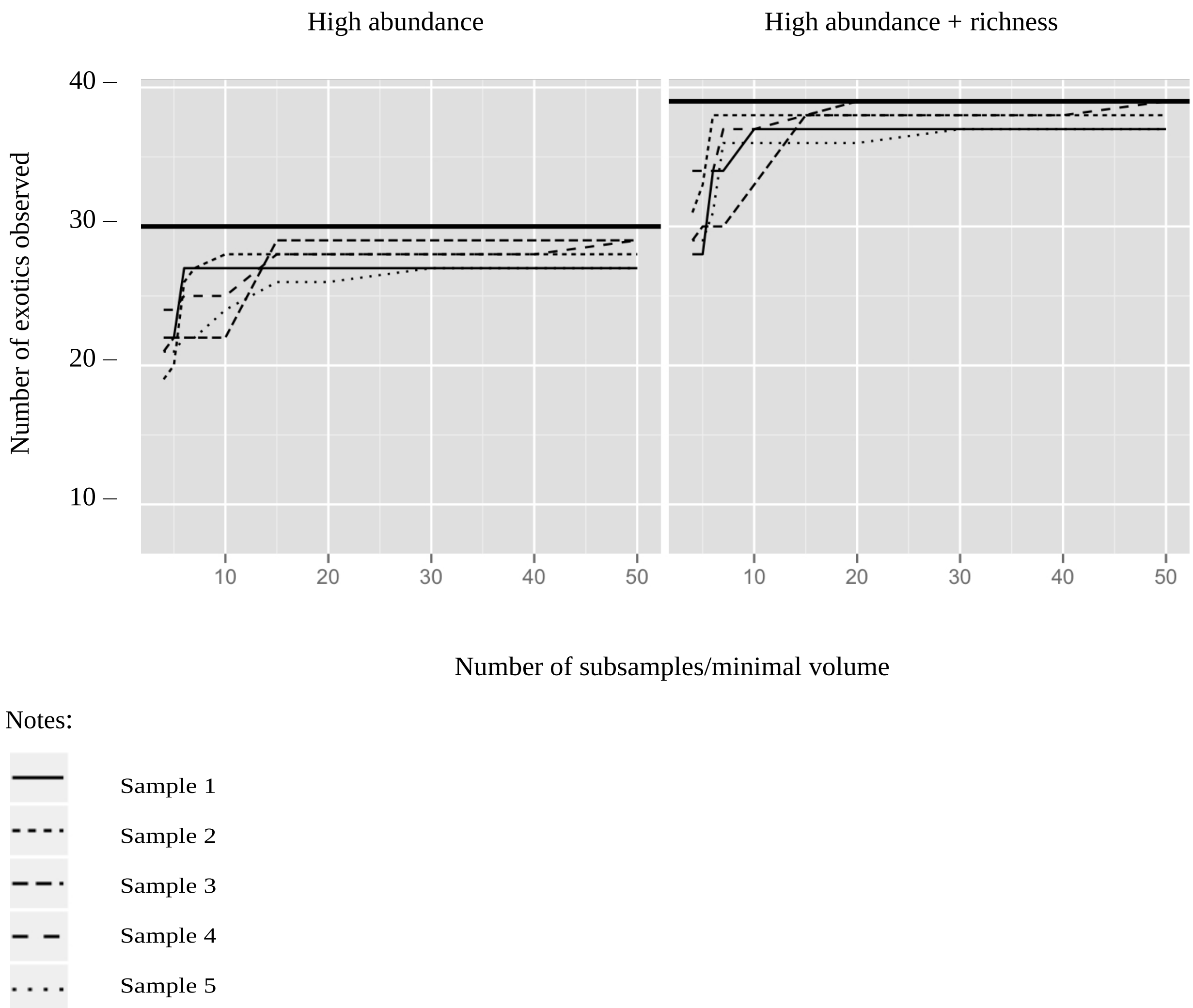


Figure 4.6 Firepit 6 datasets: increasing the SAC minimal volume. Increasing the minimal volume to 5 subsamples or alternatively 15 subsamples yields better results. Each sample is shown separately as a different line style. The thick horizontal line at 30 on the high abundance plot, and at 39 on the high abundance + richness plot indicates the number of exotics added. Figure provided by P. Molloy, labels adjusted to reflect original data (van Roggen).

The curves are created here made use of all sample data including the larger unsubsampled screen content, which are responsible for the "sharply rising line." Exotics are larger, more easily identifiable, and most importantly, not subject to subsampling. Even in firepit 6 datasets, where the

SAC approach is much improved, it is clear that the curves do not plot the capture of *common* species in the initial sampling stages and taper off as less and less common species are observed. All size grades in these experiments were equally “common,” each was introduced in the same way, in the same quantities and under the same conditions. All had a reasonably equal chance of being recovered. The sharply rising line is the capture of the non-subsampled screen content, the material that, for the most part, would be found in the 4.75 mm and 2.8 mm screens. If exotic accumulation curves reflect a similar effect using authentic archaeobotanical data, we might assume we are accounting for common and rare species when what we are most plausibly seeing is a sampling effect. I plot exotic accumulation curves for firepit 5 data for the subsampled screen content and compare the SAC approach against the 100 per cent survey (CA approach) to assess how the patterning of curves has implications for standardized measures.

The sharply rising line that flattens: asymptote and patterning

The explicit assumption of species accumulation curves (and the sampling to redundancy process) is that common species are observed rapidly in the initial sampling stages (see Tables A.1-A.6, Appendix A for a summary of exotic observations as they occur throughout the sampling process for firepit 5 data). As new species become less common (or “rare”), observations taper off. The three experiments demonstrate that there are no common and rare species in the simulations and at least one of each exotic type is recovered when sample data are pooled for a known “deposit” content. Firepit 5 provides data to revisit the patterning of the sharply rising line to see how interpretations of the curve are biased. SAC and CA asymptote are compared over the five samples for firepit 5; in only one sample did SAC asymptote match true asymptote (sample 1, 1.4 mm portion)(Table 4.4, p. 93).

Sample 1

Sample 1 data (Table 4.4) show that SAC subsampling using the current configuration of the minimal volume accounts for only one of eight available exotics in this sample. The SAC approach correctly identified exotic richness (asymptote) for the 1.4 mm screen based on the complete analysis of the screen content with increasingly poor results in the smaller screens. When all screen data are plotted (Figure 4.7, p. 94) the accumulation of data are staggered and unpredictable. The most problematic in terms of sampling effort is the .25 mm screen.

Table 4.4 Firepit 5, sample 1 subsampled screens: SAC vs. CA asymptote (cumulative number of exotics observed by screen size and subsample number).

Screen size-subsample number	Number of subsamples per screen	Cumulative number of exotics SAC*	CA*	Asymptote/minimal volume
1.4-2	14	1	1	SAC and CA asymptote
.71-3		0	0	SAC asymptote
.71-5		-	1	
.71-6		-	2	
.71-7		-	3	
.71-14	14	-	4	CA asymptote
.25-3		0	0	SAC asymptote
.25-7		-	1	
.25-19		-	2	
.25-23	52	-	3	CA asymptote

Notes:
* Counts are cumulative by screen only; CA asymptote is based on the complete analysis of the sample rather than the introduced content thus measuring the SAC approach against a reasonable standard.

Sample 2

The SAC asymptote underestimates sample content suggesting redundancy of sampling effort earlier in the subsampling process. The number of subsamples needed to achieve redundancy for both the 1.4 mm and .71 screens was eleven subsamples, nine ere required in the .25 mm screen for this dataset (Table 4.5). Exotic accumulation curves are plotted to demonstrate recovery in the subsampled screens (Figure 4.8, p. 96).

Table 4.5 Firepit 5, sample 2 subsampled screens: SAC vs. CA asymptote (cumulative number of exotics observed by screen size and subsample number).

Screen size-subsample number	Number of subsamples per screen	Cumulative number of exotics SAC*	CA*	Asymptote/minimal volume
1.4-2		1	1	
1.4-3		2	2	SAC asymptote
1.4-7		-	3	
1.4-11	14	-	4	CA asymptote
.71-3		2	2	SAC asymptote
.71-11	13	-	5	CA asymptote
.25-3		0	0	SAC asymptote
.25-9	45	-	1	CA asymptote

Notes:
* Counts are cumulative by screen only; CA asymptote is based on the complete analysis of the sample rather than the introduced content thus measuring the SAC approach against a reasonable standard.

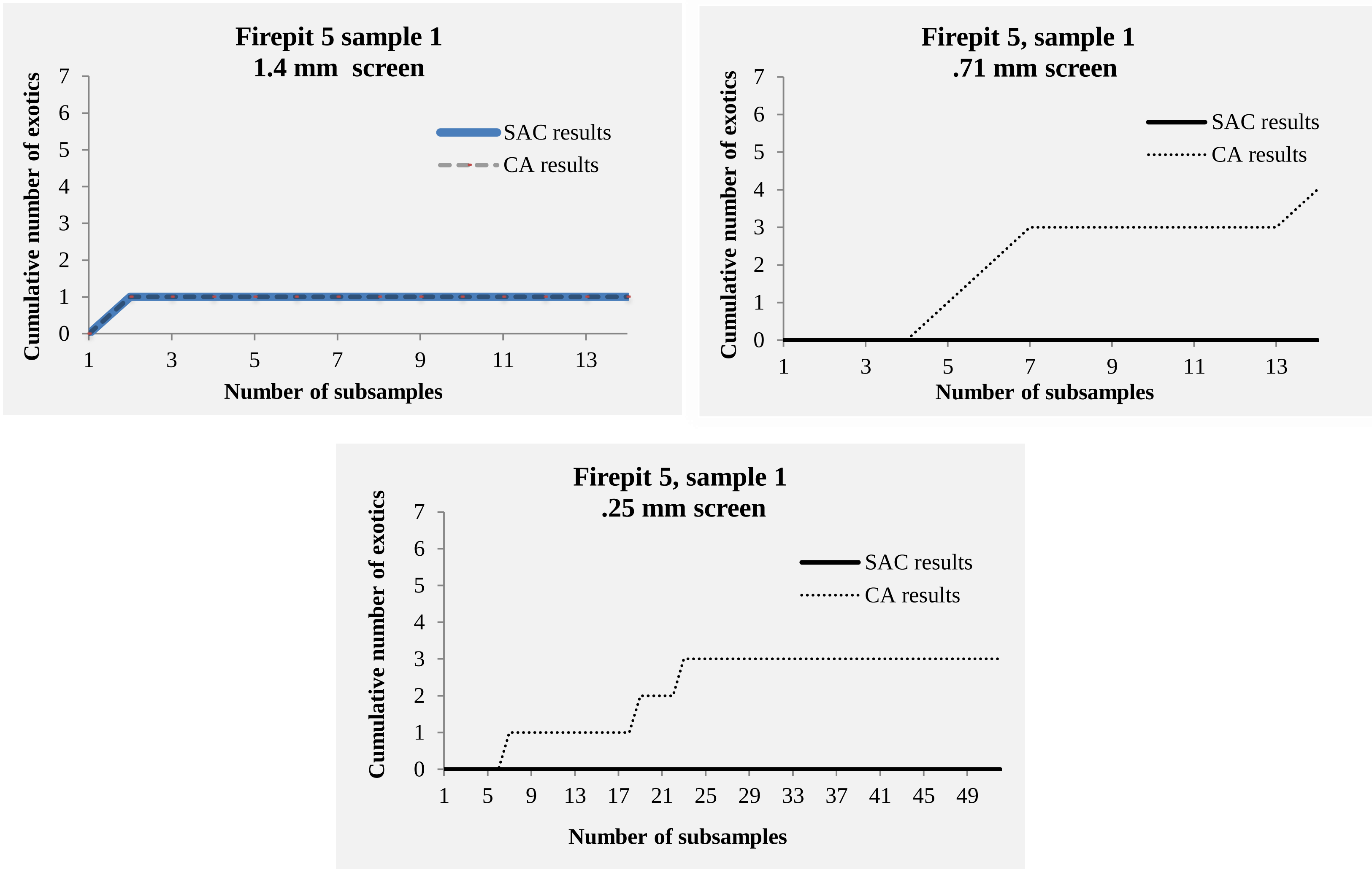


Figure 4.7 Firepit 5, sample 1: exotic accumulation curves by individual screen. All data combined comparing SAC and CA results.

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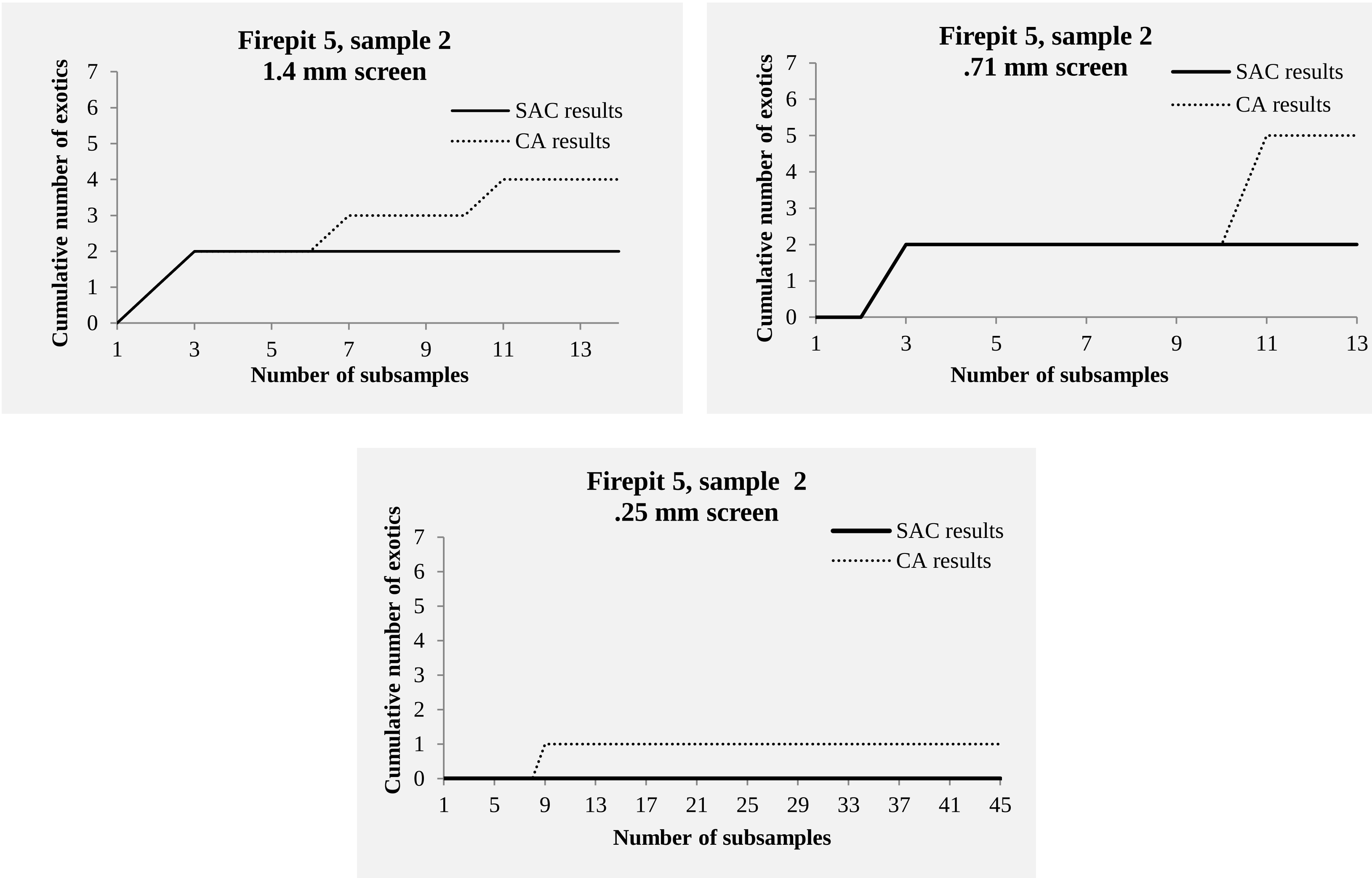

Figure 4.8 Firepit 5, sample 2: exotic accumulation curves by individual screen. All data combined comparing SAC and CA results

Sample 3

The SAC approach underestimated richness of all subsampled screens indicating redundancy of sampling effort earlier in the accumulation process based on full analysis of the sample (Table 4.6). Curves are plotted in Figure 4.9 (p. 97) show a staggered patterning of observations.

Table 4.6 Firepit 5, sample 3 subsampled screens: SAC vs. CA asymptote (cumulative number of exotics observed by screen size and subsample number).

Screen size-subsample number	Number of subsamples per screen	Cumulative number of exotics SAC*	CA*	Asymptote/minimal volume
1.4-1		1	1	SAC asymptote
1.4-7		-	2	
1.4-11		-	3	
1.4-16	19	-	4	CA asymptote
.71-3		0	0	SAC asymptote
.71-4		-	1	
.71-8		-	3	
.71-10	10	-	5	CA asymptote
.25-3		0	0	SAC asymptote
.25-13	28	-	1	CA asymptote

Notes:
* Counts are cumulative by screen only; CA asymptote is based on the complete analysis of the sample rather than the introduced content thus measuring the SAC approach against a reasonable standard.

Sample 4

The SAC approach underestimated the richness of each subsampled screen, accounting for one exotic of eleven recoverable (Table 4.7). Accumulation curves for each screen are plotted in Figure 4.10 (p. 98).

Table 4.7 Firepit 5, sample 4 subsampled screens: SAC vs. CA asymptote (cumulative number of exotics observed by screen size and subsample number).

Screen size-subsample number	Number of subsamples per screen	Cumulative number of exotics SAC*	CA*	Asymptote/minimal area
1.4-1		1	1	SAC asymptote
1.4-8	14	-	2	CA asymptote
.71-3		0	0	SAC asymptote
.71-8		-	3	
.71-9		-	4	
.71-11	16	-	7	CA asymptote
.25-3		0	0	SAC asymptote
.25-12		-	1	
.25-14	98	-	2	CA asymptote

Notes:
* Counts are cumulative by screen only; CA asymptote is based on the complete analysis of the sample rather than the introduced content thus measuring the SAC approach against a reasonable standard..

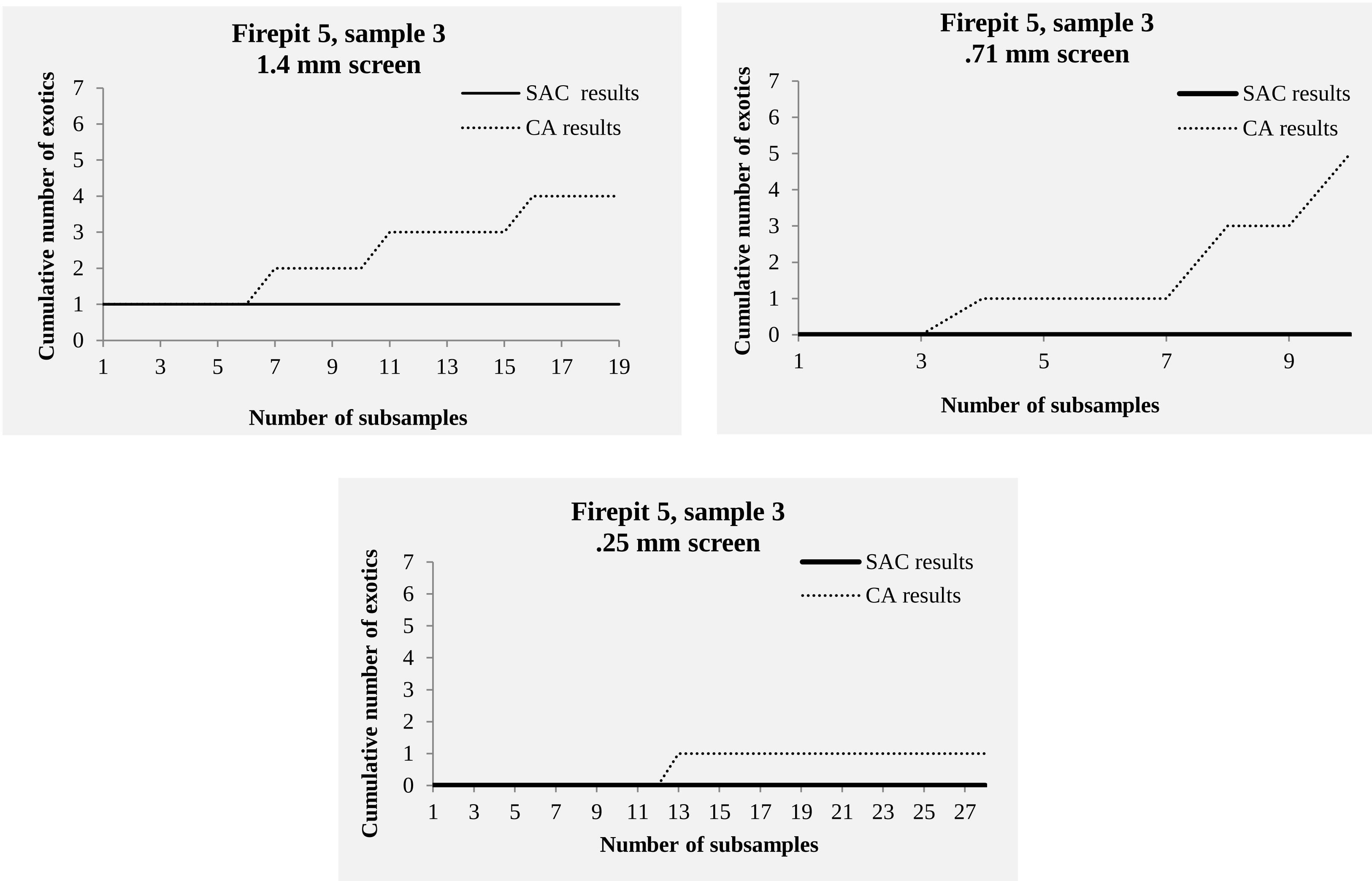

Figure 4.9 Firepit 5, sample 3: exotic accumulation curves by individual screen. All data combined comparing SAC and CA results
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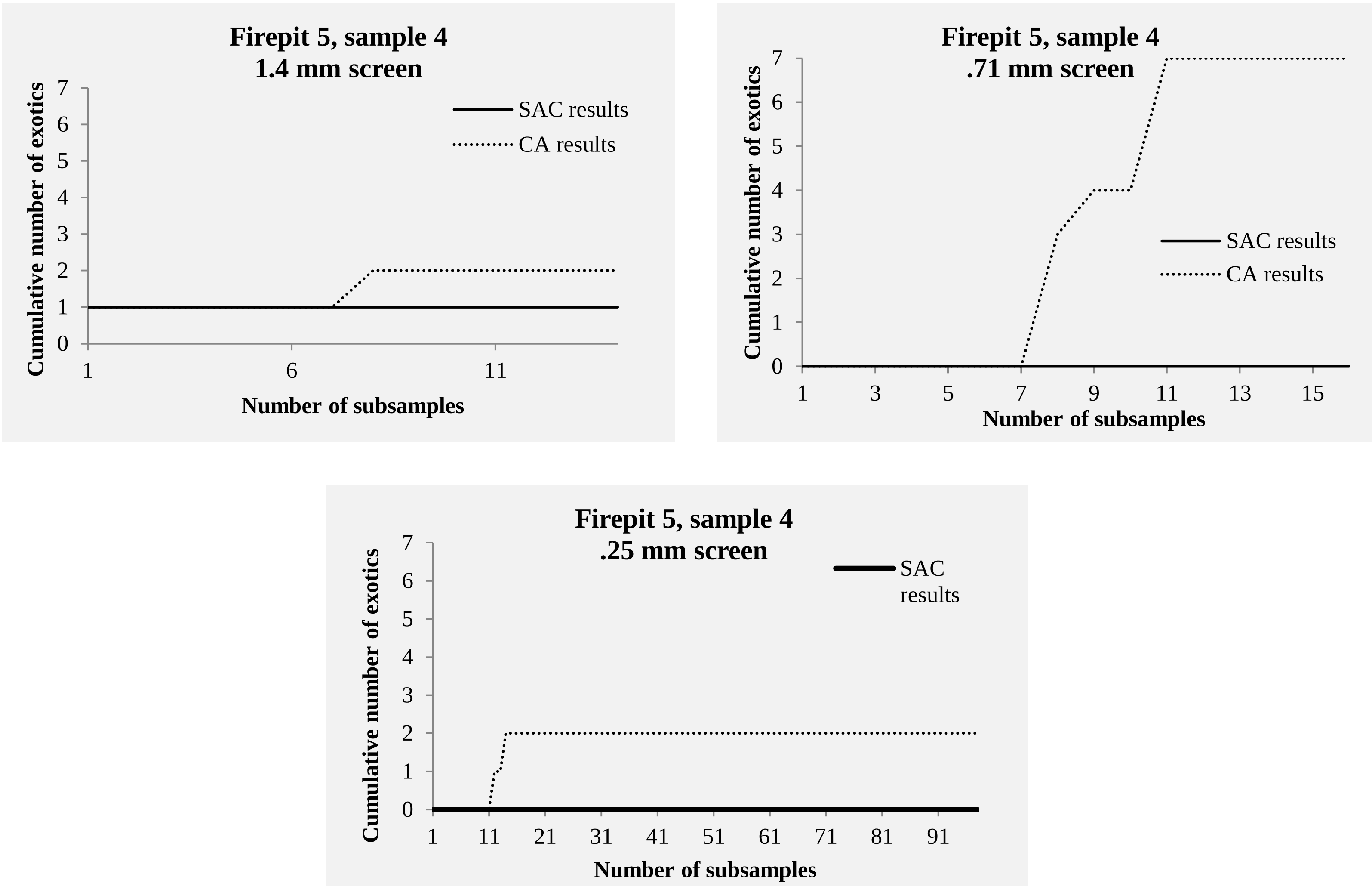


Figure 4.10 Firepit 5, sample 1: Exotic accumulation curves by individual screen. All data combined comparing SAC and CA results.

Sample 5

Asymptote was underestimated in all portions (Table 4.8). Only one of 11 available exotics in the three smallest screens was recovered using SAC minimal volumes. Similar to other firepit 5 samples, the patterning of accumulation is staggered and unpredictable (Figure 4.11, p. 100).

Table 4.8 Firepit 5, sample 5 subsampled screens: SAC vs. CA asymptote (cumulative number of exotics observed by screen size and subsample number).

Screen size-subsample number	**Number of subsamples per screen**	**Cumulative number of exotics SAC***	**CA***	**Asymptote/minimal volume**
1.4-3		1	0	SAC asymptote
1.4-5		-	1	
1.4-15	16	-	2	CA asymptote
.71-3		0	0	SAC asymptote
.71-5		-	1	
.71-6		-	2	
.71-7		-	3	
.71-10		-	4	
.71-12		-	5	
.71-19	23	-	6	CA asymptote
.25-2		1	1	SAC asymptote
.25-8		-	2	
.25-27	59	-	3	CA asymptote

Notes:

* Counts are cumulative by screen only; CA asymptote is based on the complete analysis of the sample rather than the introduced content thus measuring the SAC approach against a reasonable standard.

The patterning of accumulation for true asymptote (“CA asymptote”) suggests that only rarely is there a sharply rising line on accumulation curves for simulated samples using firepit 5 data. Recovery is sporadic and no general pattern is observed other than an overall staggered recovery.

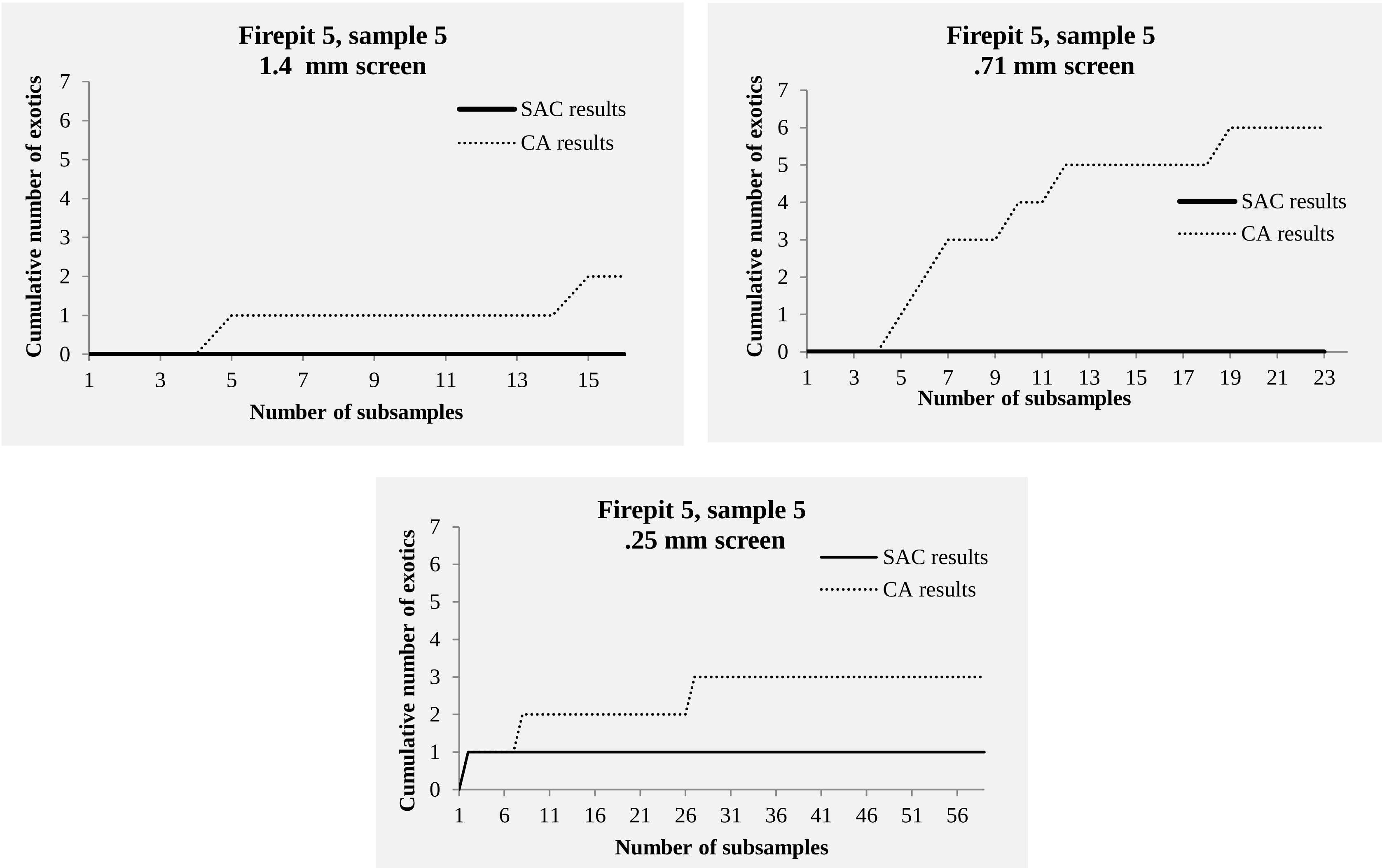


Figure 4.11 Firepit 5, sample 1: Exotic accumulation curves by individual screen. All data combined comparing SAC and CA results.

SAC subsampling effects: abundance

Subsampling also has an adverse effect on abundance in simulation. Larger exotics found in the larger screens were more likely to be recovered than species of 1.4 mm or smaller in size when using the SAC approach. It is evident that flotation (and presumably analyst error) did not have a significant impact on abundances and had no impact on the recovery of at least one specimen of every exotic species as shown in Table 4.9. Total number of specimens introduced is 30 for each exotic size grade. Recovery dips significantly in the subsampled screens.

Table 4.9 Abundance recovery for firepit 5 samples by approach: recovered number of specimens comparing SAC and CA results.

Screen size and total number of specimens introduced and recovered									
4.75 mm	**30**	**2.8 mm**	**30**	**1.4 mm**	**30**	**.71 mm**	**30**	**.25 mm**	**30**
SAC recovery									
Zea	3	*Piper*	5	*Chenopodium*	2	*Papaver*	0	*Portulaca*	0
Phaseolus	5	*Alcea*	5	*Sinapis*	2	*Trifolium*	0	*Nicotiana*	0
Cucurbita	4	*Borago*	0	*Physalis*	1	*Apium*	2	*Mentha*	1
Lagenaria	5	*Secale*	3	*Latuca*	1	*Salvia*	0	*Lobelia*	0
Helianthus	4	*Fagopyrum*	2	*Trigonella*	1	*Melissa*	0	*Origanum*	0
Tropaeolum	4	*Lathyrus*	5	*Rosmarinus*	1	*Ocimum*	0	*Erogrostis*	0
Total	**25**		**20**		**8**		**2**		**1**
CA recovery									
Zea	3	*Piper*	5	*Chenopodium*	4	*Papaver*	5	*Portulaca*	5
Phaseolus	5	*Alcea*	5	*Sinapis*	4	*Trifolium*	3	*Nicotiana*	5
Cucurbita	4	*Borago*	4	*Physalis*	3	*Apium*	4	*Mentha*	5
Lagenaria	5	*Secale*	5	*Latuca*	4	*Salvia*	4	*Lobelia*	2
Helianthus	4	*Fagopyrum*	2	*Trigonella*	5	*Melissa*	5	*Origanum*	3
Tropaeolum	4	*Lathyrus*	5	*Rosmarinus*	5	*Ocimum*	3	*Erogrostis*	5
Total	**25**		**26**		**25**		**24**		**25**

Of 150 exotic specimens (five specimens for each of six exotics, or thirty seeds per screen) added to firepit 5, 125 were recoverable based on the results of complete analysis, an 83 per cent recovery rate for abundance and 100 per cent recovery for at least one of each of unique exotic type. SAC subsampling identified only 56 specimens for a 37 per cent recovery rate for abundance and 63 per cent recovery for at least one of each exotic type. Of the subsampled screens, the least affected appears to be the 1.4 mm particle size but the results are still poor. Subsampling is not entirely at fault however. The sharply rising line also demonstrates a “sorting” effect. Specimens of larger and smaller sizes are recovered in any screen. The problem arises in the interpretation of plotted curves.

Interpretative pitfalls: accumulation patterns vs. species-area patterns

As discussed in chapter three, species accumulation curves and species-area curves measure different qualities. Accumulation curves account for the *process of sampling* by plotting each new taxa as it is observed—as observations/recovery accumulate through the sampling process. Species-area curves plot species as "different" from each other in order to get a sense of the diversity or richness of a particular habitat. In our case, the "diversity" or richness of a sample. SAC subsampling data *are tied to size* because subsampling occurs *after* sorting light fraction into size grades. Size is everything in sampling using pre-sorted light fraction. Large remains are typically wood species and domesticates, small remains are typically wild seeds or other reproductive parts and fragments. The smallest and subsampled light fraction screens are in effect the catchment for wild remains more so than any other category of ancient material. By sorting we relegate these remains to "outlier" status.

Complete analysis of samples and statistical testing demonstrates that the SAC approach significantly constrains recovery of material in the subsampled light fraction portions. In effect, this constrains the wild plant record. It does this because of the sorting process. Small remains do not have the same chance of being observed not simply because they are small but because they sort into light fraction screens that retain a microscopic bulk of extraneous materials that make it difficult to find scattered wild seeds. By sorting material prior to analysis we inadvertently impose a false grading of content and assume a common-to-rare patterning where wild seeds become rare because of retained sediment volume. Large light fraction screens do not retain sediment. The bulk of material that sorts into these screens is ancient, or if not, easily distinguished as uncharred and/or modern. The heavy fraction represents the bulk of 4.75 mm and 2.8 mm sediment and this is put aside. I have also shown that "diversity" (richness + specimen abundance) thought to propel subsampling in the smallest screens is a fallacy, although producing better individual results. So beyond these biases there is the very real problem of how the data are used to standardize a sampling strategy for site-specific analysis.

We rely on this species-area curve plotting strategy to create standardized methods for light fraction. In the following discussion I show how accumulation and area curves can be misunderstood for light fraction and used inappropriately to focus attention on particular screens for "richness" assessments. The differences are subtle, but real and can distort assessments of content. I use firepit 5 data.

<u>Firepit 5 sample 1</u>

The first occurrence of each new exotic type for this sample is plotted on two types of curves in Figure 4.12 (p. 103). This allows for an understanding of the content of the sample and where material has sorted out. The first curve (left plot) is an accumulation curve that accounts for the first observation of new exotics as they were observed/accumulated through the subsampling process based cumulative new exotics. This is in reality a sorting collection curve. Because we scan through light fraction from the larger sized screen portion to the smallest, we capture "sort" data, the new identities regardless of size that sort into the screens as we progress through analysis.

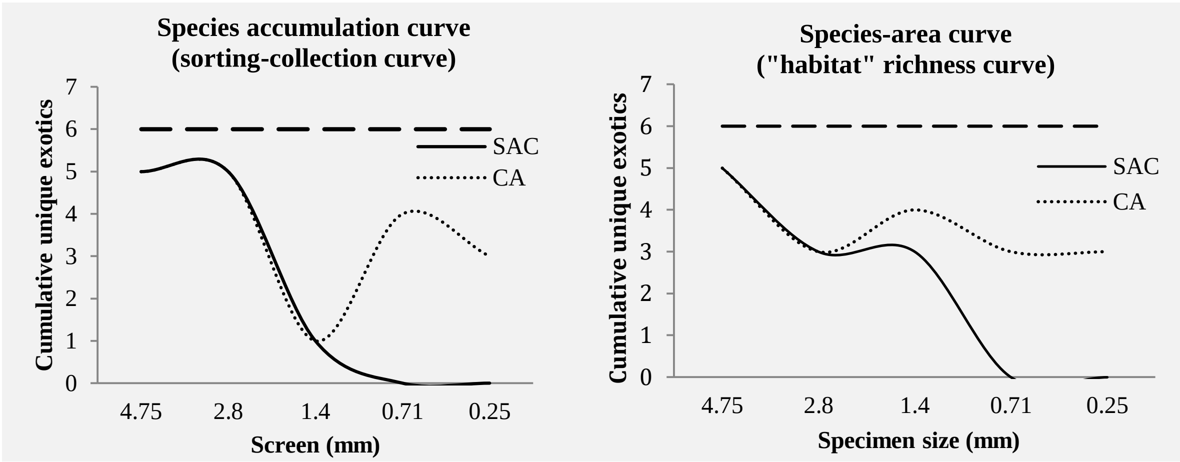
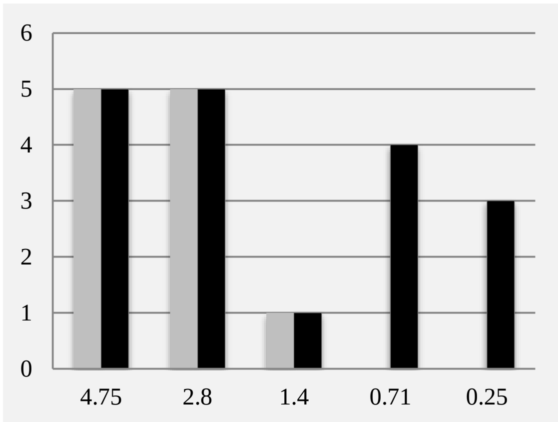


Figure 4.12 Firepit 5, sample 1: "species-accumulation" and "species-area" curve comparisons. The dashed line at six represents the number of unique exotic types added of each size grade.

The accumulation/collection curve in Figure 4.12 documents first observations of new taxa that occur through the sample scannind process that begins with the large-sized remains (4.75 mm screen sort) and ends with the smallest remains (.25 mm screen sort) The "species-area" curve (right plot) captures "content." In this curve, it is not the screen where the specimen was found but its identity as a "size," approximately 4.75 mm, 2.8 mm, 1.4 mm, .71 mm or .25 mm. As I've said, the size of archaeobotanical specimens reflects the types of seeds we are capturing (larger seeds tend to be domesticates in the American Southwest where corn, beans and squash with their large seeds are major contributors to the diet). Just glancing at the left plot, I immediately see that most of the content of the sample plotted is large, likely reproductive in nature suggesting that large remain dominate the sample. This is incorrect, because the plot reflects a collecting/sorting curve under the influence of subsampling small remains. Misinterpreted, the curve suggests that the bulk of exotics I want to recover are in the two largest screens and the two smallest screens. Based on this information, I could mistakenly assume that the 1.4 mm light fraction screen is not a productive screen. The same data plotted differently, tells me what the actual content of my sample consists of using CA data. This is my "habitat diversity" that indicates that I have many exotics of 1.4 mm in size (the exotics I selected are the larger "wild" seed types, many of which we find in ancient deposits). In both cases, the accumulation/sorting/collection and "habitat richness" curves, the SAC approach poorly estimates the best light fraction screen to concentrate subsampling effort and underestimates content. Combined these curves tell us that there are numerous exotics of 1.4 mm in size and we won't find them in the corresponding screen. Our subsampling efforts are better focused on sorting curves because they tell us where to look. Both curves put a focus on “size” but in subtly different ways. Plotted in bar graphs, the effect is obvious.



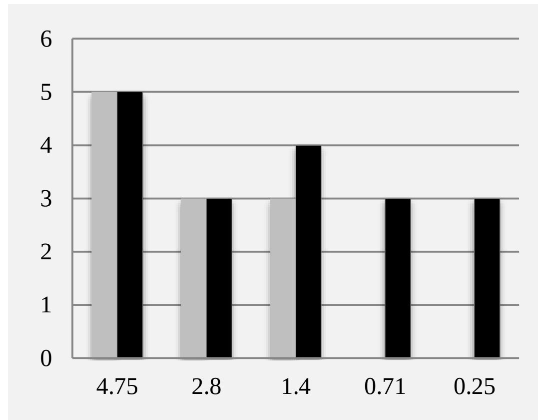


Figure 4.13 Identifying light fraction diversity, firepit 5, sample 1. Left plot, exotic “sort” data by light fraction screen. Right plot, “exotic diversity” based on specimen size. Grey bars are SAC data, black bars are CA data.

The accumulation/collection curve in Figure 4.12 (previous page) plots what the species-area curve method captures: the first observation of a new “taxon,” that is achieved through the sample scanning process and begins with large-sized remains and ends with the smallest remains. It shows where the bulk of the material sorted in a sample. The “diversity” curve (the left plot, “species-area”) plots the exotic variety present in the sample. Whether we find it or not is related to where it sorts out in the screening process. With luck, the smallest remains will sort in non-smallest and subsampled screens. Although it looks like a species-area curve, it is collected based on a species-area curve method, and it tells us about the content of a sample to some extent, it actually plots how data was collected for the sample and it is the curve that would be plotted using SAC subsampling data *for subsampling decision-making* at the outset of archaeobotanical analysis. It is the method by which decisions about how much sample volume will be assessed in order to curtail sampling effort. In this respect an accumulation curve what is actually required for standardization to manage sampling effort. The problem is, that each new deposit is an entirely different universe. The sorting process cannot be relied on to be stable across multiple samples because most samples evaluated come from different “universes” or depositional contexts. The remaining samples for firepit 5 demonstrate what is a “sorting effect” (captured by a sorting/accumulation curve) on light fraction content.

<u>Sample 2</u>

The SAC approach underestimatesx the variety of exotics in sample 2. Curves plotted in Figure 4.14 (over) represent a sorting-collection curve (left plot) that identifies the most productive light fraction portion fell into the .71 mm screen size. The species-area curve, (right plot) tells us about content, the richness of the sample that contains more 1.4 mm sized exotics equal to that of the two largest screens combined (and also equal to that of the two smallest screens combined). Whether we capture that diversity depends on whether we increase time spent on the .71 mm portion for this sample.

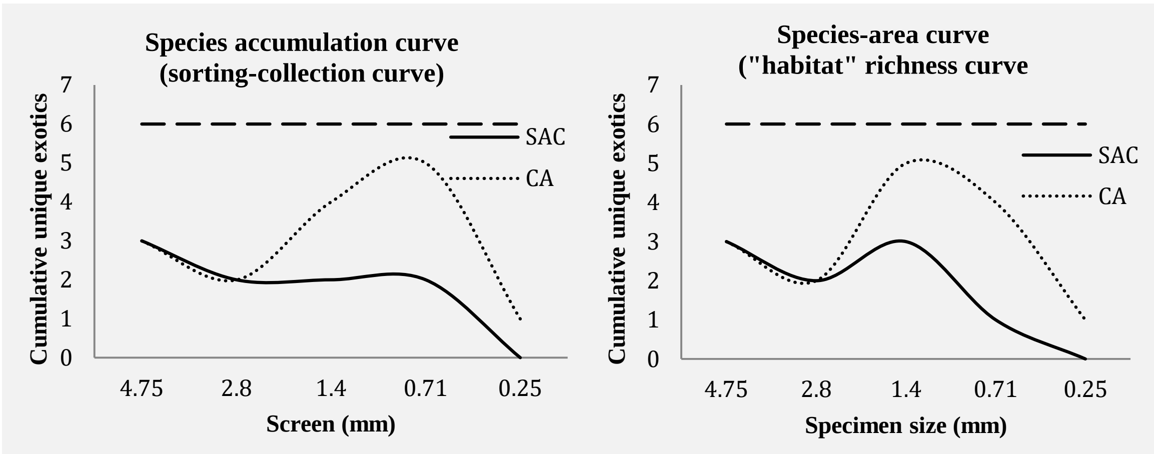


Figure 4.14 Firepit 5, sample 2: “species-accumulation” and “species-area” curve comparisons. The dashed line at six represents the number of unique exotic types added of each size grade.

Sample 3

SAC accumulation/observation curve (left plot) for sample 3 (Figure 4.15) suggests that sampling effort is most productive for new exotics of 2.8 mm in size although most new exotics accumulated most abundantly in the .71 mm screen. Small-sized exotics outweigh those of larger exotics as shown in the species-area curve for this sample (richness, left plot, Figure 4.15).

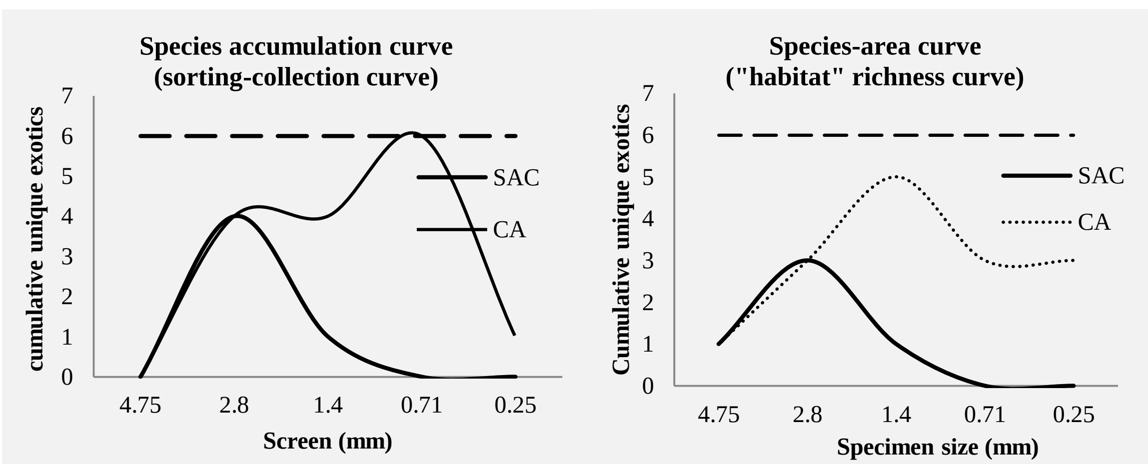


Figure 4.15 Firepit 5, sample 3: “species-accumulation” and “species-area” curve comparisons. The dashed line at six represents the number of unique exotic types added of each size grade.

The most abundant species are of 1.4 mm in size (typically wild or worked remains).

Sample 4

CA accumulation data indicate that the bulk of unique exotics pooled in the .71 mm screen (Figure 4.16, species accumulation curve, left plot) based on sorting effects. The species-area curve (CA data) identifies exotic content for the most part of 2.8 mm 1.4 mm and .71 mm in size. By using accumulation data, more effort could be directed towards the .71 mm screen that while productive, would not account for a representative sample.

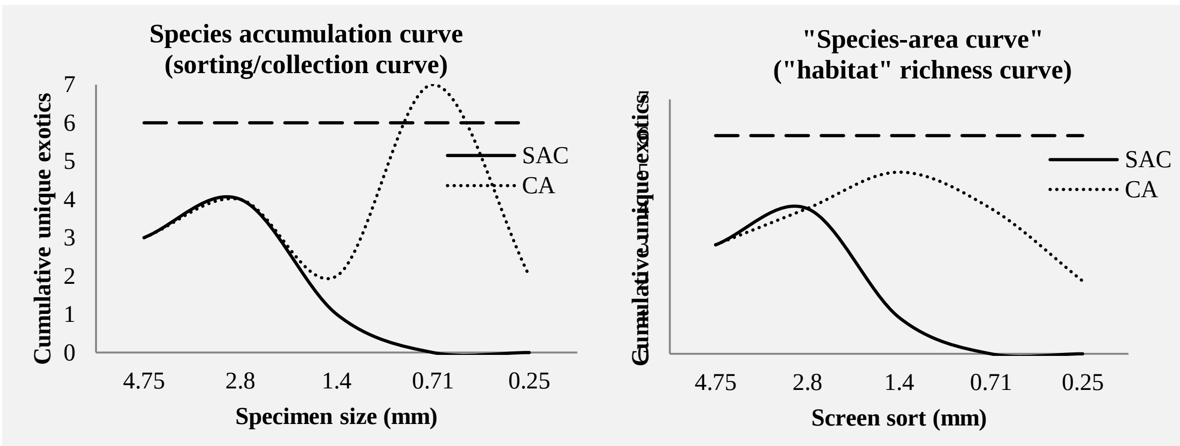


Figure 4.16 Firepit 5, sample 4: “species-accumulation” and “species-area” curve comparisons. The dashed line at six represents the number of unique exotic types added of each size grade.

Sample 5

The species accumulation curve in Figure 4.17 (left plot) shows that although six unique exotics would be accounted for in the 4.75 mm portion, an additional six new exotics pooled in the .71 mm portion as indicated by the CA curve and missed due to subsampling.

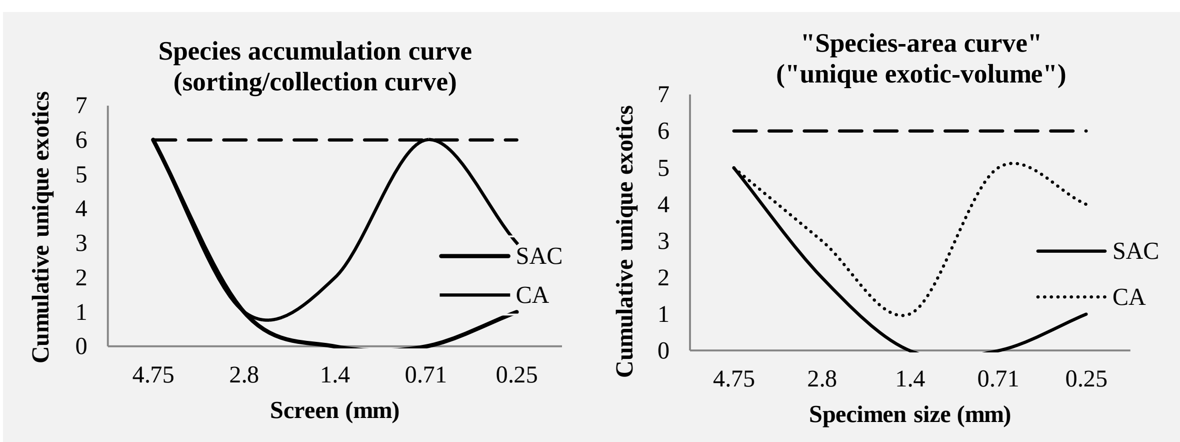


Figure 4.17 Firepit 5, sample 5: “species-accumulation” and “species-area” curve comparisons. The dashed line at six represents the number of unique exotic types added of each size grade.

The content curve (right plot, species-area) indicates less 4.75 mm-sized exotic species and less .71 mm-sized exotics. Using either CA curves as a standard accounts for the bulk of the “diversity” in the sample.

<u>Firepit 5 content</u>

Combining all data for firepit 5 indicates a “deposit-level” sorting effect that has implications for adapting the SAC strategy. The smallest remains, those exotics that sorted into the .71mm and .25 mm screens were the most vulnerable to sorting “invisibility” because of size and subsampling effects. Is there a standard for firepit 5 that would produce a representative sample? Generally, the best results come from the .71 mm screen with 31 per cent of recoverable exotics over five samples pooling in this screen (Figure 4.18).

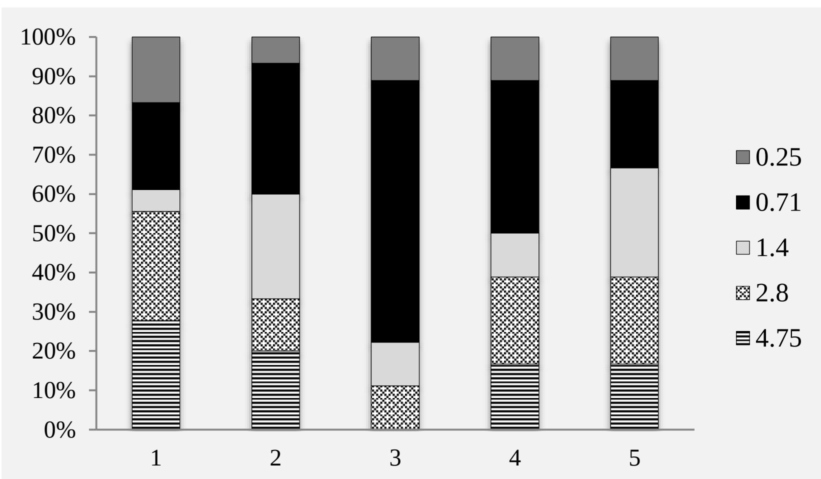


Figure 4.18 Sorting effects: firepit 5 sample data using a 100 per cent survey (CA or complete analysis).

Although the SAC subsampling process overestimates the relative importance of large remains because only the smallest screens are subsampled, the richest exotic size content recoverable for firepit 5 samples was that of exotics of approximately 1.4 mm in size. These made up 24 per cent of recoverable content. They did not typically sort into the 1.4 mm screen, however, but scatter throughout, a selection error for size is likely the cause. Surprisingly, the larger exotics when combined (that is, the unsubsampled 4.75 mm and 2.8 mm size grade seeds) accounted for 38 per cent of the total content of the firepit. The two smallest exotics, the .71 mm and .25 mm in size when combined accounted for the same percentage (38), making the 1.4 mm exotics either the most hardy or the least likely to be missed. If the SAC approach was used, this quantity would be underestimated. Figure 4.19 (p. 108) details percentage presence of each exotic type contained in firepit 5.

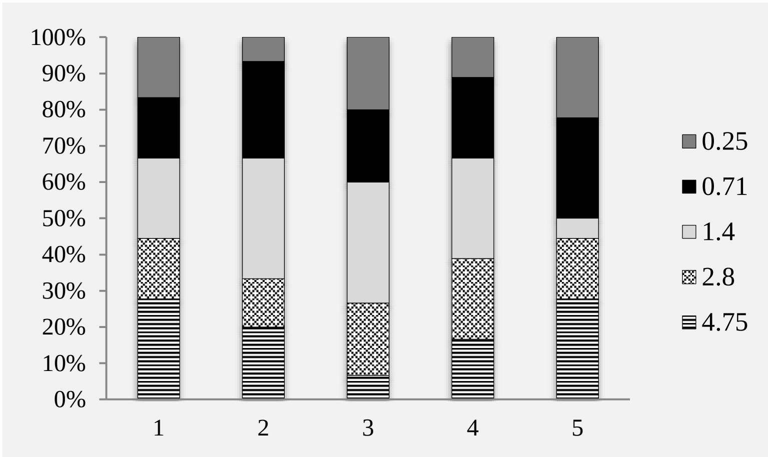


Figure 4.19 Firepit 5 exotic richness by percentage based on complete analysis of all sample content.

Figures 4.18 and 4.19 show that the productivity of particular screens is higher than others in simulation but does not necessarily reflect the size grade of the material present in the sample. There are obvious pitfalls using the SAC approach. While the "sorting curve" is a more accurate reflection of the relationship between content and volume, complete analysis of samples is the only way to be assured of representative samples.

Chapter summary

The basic assumptions of the SAC approach are found to significantly bias richness measures for experimental flotation samples limited to the content of the subsampled screens and smallest particle sized materials. There is no evidence to suggest that species and volume co-vary in standard and predictable ways in simulation other than to say the combination is unpredictable. The use of geologic screens introduces a sorting effect that is predictable, however. In five samples (firepit 5) the richest accumulation of introduced exotics was found in the .71 mm screens, a screen size that is subsampled using the SAC method. Relying on the .71 mm screen as a standard is premature, however, and a general sorting trend can not be assumed. Each light fraction screen is not a unique population but a subset of a sample and a sampled population. Reliance on the concept of asymptote through the use of curves and plotted data as an indicator of sampling redundancy is too optimistic. ANOVA results indicate that the approach is the cause of discrepancies between introduce content and recovered content. However, it is the method of light fraction processing captured by pouring off of bucket content in combination with screen sorting and SAC subsampling that creates "rarity" (and in some cases, "commonness") where potentially none, or little, exists. In the next chapter I introduce the Sand Canyon Pueblo sample study to explore if additional sampling enhances provides additional data and the interpretation of the known archaeobotanical record and the interpretation of the site.

Chapter 5 Introduction to the Sand Canyon Pueblo study

Chapter overview

The Sand Canyon Pueblo archaeobotanical record provides an opportunity to test the effectiveness of the one-litre sample analysis and light fraction subsampling strategies using real samples. The study is designed to explore richness measures with increased volume analyzed. I evaluated previously unexamined samples and subsamples to evaluate "representativeness" of sample data and make comparisons between samples from the same or similar depositional contexts previously analyzed and reported in Adams et al. 2007 (from Adams 1989a; 1989b; Adams and Bowyer 1998; CCAC 2004, CCAC 2015a; Scott and Aasen 1985). In this chapter I introduce the study and provide a review of sample selection, laboratory protocols, microscopic identification and reporting standards. Sand Canyon Pueblo samples serve as authentic repositories for cultural information. Sampling is only effective when we can be assured of some measure of "representative interpretation." For this reason the interpretative value of archaeobotanical remains is critical to archaeology.

Background

I tackle the question of sample adequacy for archaeobotanical deposits and samples through the analysis of previously unexamined samples and the re-analysis of previously subsampled Sand Canyon Pueblo (SCP) flotation samples. The study is divided into two parts, an exploration of the impact of limiting analysis to a single litre flotation sample ("bulk volume") and an evaluation of the species-area curve approach (SAC) on previously subsampled volumes. The analysis focuses on the interpretative aspects of increased volume analyzed. The research question: *does additional sampling and subsampling enhance interpretation of samples and deposits?*

To account for biases and taphonomic effects associated with flotation samples, chapters six and seven are dedicated to "context," the contemporary and archaeological history of Sand Canyon Pueblo with a focus on the deposition of the samples used in the study or contexts that provide additional information to enhance interpretative potential. Data from the Sand Canyon Pueblo database (CCAC 2004), the Multi-site Database (CCAC 2015a) and the final report (Kuckelman, ed. 2007) are used to understand sampling effects. Chapter seven is an exploration of bulk volume (the single one-litre flotation sample). The focus of chapter eight is an assessment of the effects of the SAC subsampling strategy. A summary discussion is presented in chapter nine.

The problem: “volume” and richness comparisons

The goal of any sampling strategy is to achieve some measure of “representativeness” at whatever scale that is defined. As has been outlined previously, it is a concept that is affected by numerous known and unknown biases. Cao et al. (2007:381; emphasis added) summarize the issue of “representativeness” for biological samples in three conclusive statements, statements that drive and constrain the research here:

1) *Observed* species richness is derived from data for which *true* species detectabilities are unknown.
2) Limited resources dictate that we use small samples to characterize an assemblage, which we refer to as the collection of organisms of interest within a specified space.
3) Such samples usually capture an unknown proportion of the species occurring in an assemblage.

These statements condense the major dilemmas of any sampling situation in a way that is immediately evident for archaeobotanical analysis and clearly applicable to the Sand Canyon Pueblo study where the true recoverable and identifiable botanical content of the original deposits is unknown. The study is not meant to quantify “representative” botanical content of SCP samples but to explore if more samples and subsamples provide additional information. As will become clear in chapter six, temporal and spatial control of samples during excavation was challenging and comparisons between new and previously analyzed samples are assumed problematic as a result. My results can only be an exploration of new information that may provide enhanced understanding of the human actions associated with plants at SCP. In the case of the exploration of the species-area curve (SAC) approach, new data are used to plot my observations of ancient remains to assess the degree to which the approach reflects typical ecological species-area or species accumulation patterns. These are patterns we rely on to estimate “the last new species” through managed volume. My assumption is that if the richness of a deposit or sample is known more comprehensively, then assessments of what can be deemed “adequate” for those samples can be made based on the reality that the very nature of archaeobotany is biased by many factors not least by subjectivity. I quantify my results based on a comparison of taxa counts and interpretative “values,” or inference potential. Several problems arise: the effects of standardized volume and how this is achieved (different sediment compositions and measurement by different technicians), the identification and quantification of remains (what to count and what not to count) and how best to qualify the data in terms of meaningful cultural information. An exploration of the effects of volume and assessments of what constitutes “richness” in archaeobotanical samples is considered. I am concerned with two major biases that act on authentic archaeobotanical samples—the volume component of sampling and subsampling and the quantification of botanical richness. Both are subject to individual analyst interpretation.

Measuring trends of individual analysts call into question the concept of defined volume amount and whether volume can be relied upon as a comparative standard. Understanding "volume" is important because the SAC approach is entirely volume-dependent both to trigger the application and to identify the cut-off point of subsampling. An exact or at least consistent under- or over-measurement of volume is required. For me to suggest that my measurements are equal to those of previous analysts would be overly optimistic. In addition, the 1.4, .71 and .25 mm particle sizes of light fraction from any flotation sample that measures 50 ml or more in total light fraction volume are subsampled using the approach (Adams 2004:para. 25). This volume, too, can vary in accuracy because of the varying particle size content of the sample. While the total quantity of light fraction of a sample may be less than 50 ml and not deemed to require subsampling, the amount of residual material that pools in the smallest screen sizes is often unmanageable in terms of sampling effort and can vary between samples. To borrow again from Thomas (1978:232), this is the "magnitude of debris" problem at a microscopic scale. Deciding which "species" count in archaeobotanical analysis is problematic also.

Identifying and defining botanical richness

The analysis of light fraction is based on the identification of family, genera, species (with exceptions) and unique parts (Adams 2004). These same categories propel or limit subsampling using the SAC approach. The purpose of exceptions made for unique parts is to include a measure of interpretative potential into the calculation of sample "richness." The unique parts category takes into account the interpretative potential of two different parts of the same genus or species. An example is *Amelanchier* (serviceberry) wood vs. *Amelanchier* reproductive parts such as berries or seeds. If both specimens are present in a sample, inference potential based on parts could account for the use of serviceberry as a fuel wood and the accident discard of edible fruits as food. In the case of "species," there are also exceptions. Pine is an example. Pine charcoal is already identified, *Pinus edulis* (pinyon pine) charcoal found later does not propel further SAC subsampling because pine has been already accounted for (Adams 2004). The first exception to the SAC rules accounts for inference potential of different parts, in the second exception, inference potential of species types is limited.

Identification standards vary between analysts also. Plant remains are identified based on morphological structures that match or compare well to genera or species as characterized in botany. These identifications are impacted not only by condition of the remains but also by the subjective assessments of sufficient morphological "identifiers," the characteristic structures that have survived. It is later in the analytical process, these identities are interpreted as “human use” categories such as food or fuel. What is identified or identifiable by one analyst may not be by another. Consequently one analyst finds reason to continue subsampling, another does not. The impact is uneven accounting that alters interpretative potential. Uncharred remains are another limitation on SAC subsampling. Uncharred materials are not considered “ancient” and therefore, do not trigger further subsampling. Uncharred material provides meaningful information even if modern in origin. Disturbance effects or mixed deposits suggest caution is required when constraining subsampling by not accounting for new uncharred material.

To explore how we can quantify a method without resorting to simply a new charred genera list (with notable exceptions), I shed light on representative sampling using a quantification of an expanded “taxonomic” richness, a measure that includes assessments of morphological characteristics (genera/species/parts) and add ecological, anthropological, and cultural realities associated with ancient, used, botanical “identities.” Genera and species accumulation methods do not, on the surface, accomplish the greater goals of archaeobotany that aims to explore human lifeways but from the perspective of anthropological/cultural behaviour. By utilizing a broader definition of taxonomic richness qualities of “human use, human manipulation and disturbance” takes precedence because this is the context of samples. Rather than a species-area or species accumulation “curve,” a broader view of taxonomic richness is measured through an interpretative process that imposes additional sampling or subsampling until no new useful *information* is achieved. This requires moving into the greater cultural context of the samples. I synthesize research previously published on the Sand Canyon Pueblo site in chapter six and seven that provides the contextual background for a deeper exploration of the plant evidence.

Scope of analysis

The limited availability of comparable SCP samples dictated not only the samples that could be used for this study, but also how the resulting data could be evaluated. Sample selection reflects decisions made in response to the real difficulties of temporal and/or spatial control for archaeobotanical samples. None of the data are statistically rigorous and no significance testing is attempted.

Exploratory study part 1: “bulk volume,” the one-litre sample

It is unclear whether, or to what degree, a single one-litre volume is adequate to provide a representative sample of a bounded SCP archaeological deposit but context plays a significant role. In some cases, more than a single litre had been processed and examined in previous years. I use available data for comparison purposes regardless of total pre-flotation sample volume. In many cases, additional samples are still unanalyzed and curated and thus the total recoverable contents of the original deposit are yet unknown. Because there are so few cases where the entire deposit was processed, the analysis of flotation volume is a comparison of new information against what is already known of plant use in individual deposits at SCP.

Exploratory study part 2: species-area curve subsampling

I assess the effects of the SAC approach by completely analyzing unexamined residua of previously analyzed and subsampled light fraction. Due to lack of available samples with unexamined material, only the .71 and .25 mm particle sizes of ten samples are used. These particle sizes are the most problematic in terms of time and the effort required for microscopic analysis and demonstrates the burden of sampling effort at these particle sizes. My data in combination with the previous data represent the known population of the samples.

Methods and materials

Sample selection: general requirements and rationale

I approached sample selection in two ways: for "bulk volume," by identifying matches from samples taken from the same deposit or similar deposits where unanalyzed samples were available; and, for SAC subsampling, by selecting previously analyzed samples that had been subjected to SAC approach and had unexamined light fraction available for analysis and comparison. The most productive sample types were chosen and consist of samples excavated from primary and secondary refuse contexts for their productivity. The general context, a review of potential biases, and a description of how the data are interpreted, follow.

Archaeological and analytical contexts

All selected flotation samples were collected in the field in either 1985, 1988, 1989, 1991 or 1993 based on the research goals of the Sand Canyon Pueblo project (Adams et al. 2007; further detail presented in chapter six). Volumes are in the range of the standard one-litre routinely collected by CCAC researchers (Adams 1989b:5; Bohrer and Adams 1977:13). When one-litre samples were not available, samples of less or greater volumes are used. Wagner (1988:29) describes the volume problem as, "different sediments, a multitude of ancient behaviour pattern leading to differential deposition and the unique post depositional histories of the deposits studied." As I previously noted, this makes "volume" a fuzzy concept, although obviously practical. Small samples may be highly diverse or concentrated and should not be overlooked. I justify the use of these greater or lesser amounts because the original pre-flotation sediment volume of one litre is less critical than the processing, screening and subsampling volumes of light fraction that persist. At least one sample of apparently minimal pre-flotation volume (sample SC2) yielded new taxa/parts to Sand Canyon Pueblo (also new to surrounding sites), making it an important sample even though it appeared to measure considerably under the standardized sample volume. The criteria for selection of samples included comparing samples from similar features in the same depositional location or comparing samples from similar locations (similar locations of function or use). I re-evaluated the tree-ring data for the site (CCAC 2004, 2015a; Kuckelman et al. 2007) and propose a decade/behaviour scheme to provide a reasonable basis for temporal comparison. Cultural behaviour changes based on the data provided in these sources are linked to decades of occupation. If there are problems with temporal or spatial control over selected samples, those factors are cautiously put aside based on the reality that the duration of the SCP occupation lasted a short thirty years (approximately) and the information sheds light on plant use across the span of occupation and the site as excavated. This study provides a number of additional insights regarding flotation analysis and contributes new information about the Sand Canyon Pueblo people and the occupation. I use two methods for comparison.

Accounting for diversity/richness

Botanical remains are deemed to represent ancient activity when charred (Minnis 1981:147); however, environmental conditions such as those around Sand Canyon have resulted in the preservation of ancient uncharred remains. An example from this study is the recovery of a quantity of uncharred, broken (seemingly smashed) squash (*Cucurbita* sp.) in a sample that is clearly ancient in origin. These were not included for comparison purposes due to the charred = ancient constraint imposed on SAC subsampling, but are documented for their inference value. Abundance/density of individual taxon is not the focus of this evaluation although numbers of specimens are recorded. I compare richness measures by counting new taxa as quantities of new "variety," and in terms of interpretative value/new information. In the case of SAC samples, new taxa are viewed from these perspectives and through accumulation patterning. Interpretative categories conform to the research goals as outlined in final SCP report (Adams et al. 2007). A review with additional comments from me is presented in Table 5. (pp. 115-116.)

Interpretative value

Interpretative value conforms to inferred ethnobotanical significance suggested in the original analyses (Adams 1989a, 1989b, 2007; Adams and Bowyer 1998; Adams et al. 2007; CCAC 2004; Scott and Aasen 1985). I explore the data as evidence of traditional practice based on historic analogues. I include ecological, biological and ethnobotanical data and meet the original SCP archaeobotanical research goals: to clarify the role of plants in the subsistence economy of Sand Canyon through the interpretation of potential contributions to fuel, food and other uses (Adams et al. 2007). I provide an outline of potential interpretative values for Sand Canyon Pueblo archaeobotany (Table 5.1, over).

Table 5.1 Archaeobotanical interpretative categories for Sand Canyon Pueblo: food, fuel and other (adapted from Adams et al. 2007, Table 12).

FOODS

Domesticates

Corn (*Zea mays*), beans (*Phaseolus*), squash/gourd (*Cucurbita/Lagenaria*):

- Evidence of these types may support inferences that agricultural practices are to a greater or lesser extent the focus of much subsistence activity.
- Could indicate the use of newly harvested or stored domesticates; absence may be correlated to season.
- Fragmentation may infer evidence of specific processing activities involving domesticated plants.
- Depending on depositional locale, may suggest differential use of plants, or special use of certain combinations.
- Charred cobs with intact kernels suspected as remains of food may also suggest that there is a lack of concern over food waste as resources are plentiful.

Wild native plants

Weedy growth habit: these are plants that often have high seed productivity, are fairly easily harvested and thrive in disturbed areas such as agricultural fields. Some examples include: cheno-am (*Chenopodium* or *Amaranthus*), grasses (*Stipa*-type), groundcherry (*Physalis*), sunflower (*Helianthus*), winged pigweed (*Cycloloma*), woolly wheat (*Plantago*).

- Presence might be linked to seasonality or the use of stores.
- Nonlocal plant could indicate collection beyond the site catchment or infer trading relationships with nonlocal groups.
- Depending on differences between domesticates and wild species, may suggest greater dependence on domesticated resources over wild foods or vice versa.
- May signify cultural preferences or a response to food shortage.
- Different wild types found in associations may provide evidence of a particular cuisine or specialized use.

Nonweedy growth habit: these are plants that thrive in well-established vegetation, can be lower in productivity (may not produce fruit every year), and are often more difficult to acquire or acquire a usable quantity. Examples include the reproductive parts of: bindweed (*Polygonum*), bulrush (*Scirpus*), juniper (*Juniperus*), prickly pear cactus (*Opuntia*), serviceberry/peraphyllum (*Amelanchier/Peraphyllum*), sumac (*Rhus*) and yucca (*Yucca*). The edible and desirable nuts of pinyon pine (*Pinus edulis*) are susceptible to environmental conditions for production of seed. The presence of these types may reflect cultural preferences in spite of lower productivity. In the case of pinyon, masting events and potential human impacts on scheduling and collection of the nuts may be linked to environmental conditions or overharvesting.[27] The presence of nonweedy plants,

- Could indicate food stress or specific resource declines by the presence of less desirable, or more difficult to acquire resources or to infer new or changing food preferences.
- May represent a wider range of resource exploitation and timing of human collection activities.

continued...

[27] Redmond et al. (2012:1) define masting events or mast seeding as episodic reproductive events. Mast seeding is typical of pinyon and other pine types. Episodic nut production would have been of great interest and import to ancient populations. These events are influenced by “novel climate”—the fluctuation to favourable conditions and higher available moisture during the three growing seasons (2-3 years) required to initiate the production of cones in these species (6). Redmond et al. (2012) found that longer-term temperature-related stress may be a factor that leads to decline in seed cone production for pinyon. Other influences include shifts in higher variability in annual biweekly temperatures during late summer that seemingly provides the reproductive cue to begin the production of cones (Forcella 1981; Redmond et al. 2012). Landcare Research (online;

Table 5.1 Archaeobotanical interpretative categories for Sand Canyon Pueblo: food, fuel and other (adapted from Adams et al. 2007, Table 12) continued.

FUELS

Non-shrubby[a] taxa (trees): these are plants that dominate the forest cover around SCP (Great Basin Conifer Woodland). Examples include various species of juniper (*Juniperus* sp.) and pine *(Pinus edulis, P.ponderosa*)

- Typically represents evidence of locally available tree species, or species located further afield (*P. ponderosa* is found today at Ute Mountain, approximately 30 km from SCP).
- Potentially indicates the re-use of old tree timbers from abandoned structures (in combination with other evidence).
- The properties of the wood type may infer particular preferences such as higher heat produced or longer burn times.

Shrubby taxa (shrubby growth habit): these are shrubs of the Great Basin Desertscrub communities found in the understory at SCP. Examples include sagebrush (*Artemisia*), saltbush (*Atriplex*), oak (*Quercus*).

- Could reflect evidence of special use if specific species can be linked with particular activities in unique depositional contexts.
- Depleted tree resources could prompt the use of shrubs or re-use of shrubby roofing materials from abandoned structures.

Maize/Corn (Zea mays): cob remains that do not hold kernels are thought to represent fuel. Persisting kernels would likely place them in the domestic food category. Ethnographic use of maize cobs as fuel is well known. If kernels are present but fuel use still suspected, the remains may support an interpretation that food waste was not a concern and food resources were plentiful.

Tinder materials: applies to parts of shrubby or non-shrubby taxa, or other fragmented materials. Typically juniper scale leaves and twigs and pine bark scales are considered to represent tinder.

- May hint at the ethnographic use of specific materials recorded for certain historical activities by native groups that include other uses.

OTHER

Ecological indicators: includes assessments of specific plant phenology for interpreting season of use. Biology of particular species offers a line of evidence for inferred human food, animal feed, or for use specific for structural or chemical properties, such as cordage (*Yucca* leaves) and medicine (pharmacological potential).

Worked materials: specimens which clearly demonstrate evidence of human manipulation where

- Human use is inferred based on fragmentation or cut marks.
- Context of specimens can support interpretations of daily or specialized activities or products.

Unknowns: Evidence of human manipulation either botanical or otherwise is often captured in flotation samples. Specific identification may be less than ideal. Fragmentation plays a role in the category of "unknown" and fragmentation can represent human alteration.

Notes:

[a] Non-shrubby plants are usually defined as a tree/woody plant having one well-defined trunk at least two inches in diameter and a height of at least ten feet (Elmore 1976:6)

[b] Shrubs are categorized as having more than one stem, less than two inches in diameter, a height of less than ten feet and an unidentified crown (Elmore 1976:6).

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emphasis added) defines mast seeding as the production of *unusually high quantities of seed* that occurs in some plants and *in some years*. Ancient populations would have been highly tuned to these events and lack of evidence of pinyon nuts or nut fragments in ancient Pueblo sites may hint at drought and subsistence stress not only for the initiation of such conditions, but also for inferring shifts in the timing of weather patterns and temperatures. Additional information on the economically important pinyon pine is provided in Appendix C.

Research design

Two sets of flotation samples are evaluated for the study for a total of 30 “new” samples. Samples are assessed individually and inference potential is proposed and discussed.

Sand Canyon Pueblo study part 1: “bulk volume,” one-litre flotation volumes

Twenty previously (*n* = 20) unanalyzed samples were selected to test whether the analysis of an additional one-litre flotation volume contributes additional taxa when compared to previously documented data. Ten samples (*n* = 10) were collected from primary refuse contexts (a selection of burned spot, firepit, and hearth deposits). Ten samples (*n* = 10) were collected from secondary refuse contexts categorized as middens and general trash accumulations. The samples are labeled FV (Flotation volume) 1-20, comparison volumes, or “CV” samples provide the known population. FV sample selection is outlined in Table 5.2.

Table 5.2 "New" flotation samples (bulk volume evaluation).

Sample label	Deposit type	Feature type	Sand Canyon Pueblo study unit	SCP flotation sample no.
FV1	Primary refuse	Burned spot	Arbitrary Unit 1, 2 x 2 meter grid	PD 728, FS 1
FV2	Primary refuse	Burned spot	Structure 1003, masonry surface	PD 816, FS 2
FV3	Primary refuse	Firepit	Nonstructure 1000, extramural surface	PD 849, FS 2
FV4	Primary refuse	Firepit	Structure 1005, masonry surface	PD 847, FS1
FV5	Primary refuse	Firepit	Structure 1008, masonry surface	PD 875, FS 2
FV6	Primary refuse	Hearth	Structure 400, kiva, type unknown	PD 1454, FS 9
FV7	Primary refuse	Hearth	Structure 517, kiva, type unknown	PD 1481, FS 3
FV8	Primary refuse	Hearth	Structure 601, kiva, type unknown	PD 1530, FS 2
FV9	Primary refuse	Hearth	Structure 1010, kiva, type unknown	PD 1432, FS 14
FV10	Primary refuse	Hearth	Structure 1206, aboveground kiva	PD 243, FS 5
FV11	Secondary refuse	Midden	Nonstructure 209, midden	PD 184, FS126
FV12	Secondary refuse	Midden	Nonstructure 515, midden	PD 701, FS 40
FV13	Secondary refuse	Midden	Nonstructure 803, midden	PD 1008, FS 112
FV14	Secondary refuse	Midden	Nonstructure 1214, midden	PD 359, FS 233
FV15	Secondary refuse	Secondary refuse	Nonstructure 1000, extramural surface	PD 839, FS 145
FV16	Secondary refuse	Secondary refuse	Nonstructure 1500, multiple study type	PD 1124, FS 186
FV17	Secondary refuse	Secondary refuse	Structure 800, aboveground/great kiva	PD 1091, FS 17
FV18	Secondary refuse	Secondary refuse	Structure 1507, masonry surface	PD 1055, FS 4
FV19	Secondary refuse	Secondary refuse	Structure 1511, masonry surface	PD 1259, FS 35
FV20	Secondary refuse	Secondary refuse	Structure 1513, masonry surface	PD 1208, FS 7

Part 2: species-area curve subsampling (“SC” samples)

I used 10 (*n* = 10) previously analyzed and interpreted samples to test the effectiveness of the SAC approach (Table 5.3). Five (*n* = 5) were collected from primary refuse contexts; five (*n* = 5) were collected from secondary refuse contexts. All had been subsampled and had unexamined light fraction available. Due to lack of appropriate samples, assessment is confined to the two smallest particle sizes only (.71 and .25 mm size). Samples for this analysis are detailed in Table 5.3 (over).

Table 5.3 Species-area curve testing samples.

Sample label	Deposit type	Feature type	Sand Canyon study unit	SCP flotation sample no.
SC1	Primary refuse	Firepit	Nonstructure 1000, extramural surface	PD 609, FS 3
SC2	Primary refuse	Firepit	Structure 1002, masonry surface	PD 599, FS 3
SC3	Primary refuse	Firepit	Structure 1527, masonry surface	PD 1543, FS 1
SC4	Primary refuse	Hearth	Structure 102, aboveground kiva	PD 147, FS 4
SC5	Primary refuse	Hearth	Structure 600, aboveground kiva	PD 1582, FS 4
SC6	Secondary refuse	Midden	Nonstructure 109, midden	PD 786, FS 8
SC7	Secondary refuse	Midden	Nonstructure 515, midden	PD 701, FS 41
SC8	Secondary refuse	Midden	Nonstructure 803, midden	PD 1008, FS 113
SC9	Secondary refuse	Midden	Nonstructure 1214, midden	PD 357, FS 51
SC10	Secondary refuse	Secondary Refuse	Nonstructure 513, extramural surface	PD 715, FS 5

Sample processing

Flotation

SCP samples were collected over a series of field seasons and processed in various years by different researchers. Some differences in the processing are noted (Adams et al. 2007:para.8). Samples collected before 1991 (SAC Samples: SC numbers 1, 2, 4, 6, 7, 9 and 10) were processed using flotation methods summarized by Adams (1993a):

- The excavated samples were washed through a 1/16-inch mesh screen and the screened remains then submerged in water with the floating organic material skimmed off using a tea strainer (195).
- Samples collected after 1991 (Flotation Volume Sample FV6 and SC samples 3, 5, 8) were processed as summarized by Schaaf (1981) using a screening process incorporated into a flotation process. This method consists of pouring the original sediments into a container of water over a set of graduated geologic screens of 4.75, 2.8, 1.4, .71, and .25 mm particle sizes, thereby combining flotation with the screening normally applied to the dried light fraction. The method is repeated until the majority of the organic material is freed from the original sediments (Adams, 1993a:195-196; Schaff 1981).

Some of the FV samples I selected were unprocessed. These were requisitioned from the Anasazi Heritage Center (Dolores, Colorado) and floated in 2008 by CCAC laboratory staff following Ortman et al. (2005), described in chapter two. The light fraction was dried and shipped to me for screening and analysis under the microscope. The remaining material (heavy fraction) is curated at the Anasazi Heritage Center, Dolores, Colorado.

Analytical methods

<u>Microscopic analysis</u>

I used a dissecting binocular light microscope under 7X to 45X magnifications. Charred wood specimens were identified based on morphology seen on a fresh transverse (cross-section) break (Adams 2004:5). Non-wood materials were examined on all views if required. Specimens are identified according to the standards set out by the CCAC Environmental Archaeology Program and conform to CCAC flotation taxa and part codes. Both scientific nomenclature and common names are used; terms conform to Welsh et al. (1987). Newer designations follow the United States Department of Agriculture Natural Resources Conservation Service PLANTS Database (USDA NRCS 2009, 2014, 2015).

As outlined by Adams (2004), some specimens are identified with a combination of two genus names separated by a slash. This less specific designation accommodates for the difficulty in distinguishing between taxa that share similar morphologies. "Chokecherry/rose" (*Prunus/Rosa*) charcoal is an example. Ring and vessel patterning on cross-section view can lack the detail necessary to distinguish between them. By incorporating two potential types, a more descriptive identification is made rather than merely "angiosperm, unknown." As per Adams (2004), all combined genus designations are alphabetical and the order of reporting does not reflect a ranking of characteristics. Similarly, the term "cheno-am" refers to seeds that could either be from the genus *Chenopodium* (goosefoot) or *Amaranthus* (pigweed). Combined forms suggest that the specimens were not preserved well enough to apply a finer level of identification (Adams 2004:para. 3-4). Unknown botanicals, which occur either frequently or can be described on the basis of consistently preserved morphology, are named and/or described and can be found in Appendix C. Photographs of many specimens recorded in the study can be found in Appendix D.

All identifications are classified as "types," with a "-type" following the identification to demonstrate that archaeobotanical specimens "look like" particular family, genera, species, or other categories based on a confident or confident-enough analysis of morphology but allows for the possibility that other, similar plants in the same family may also reflect similar parts (Adams 2004). While in Cortez, I made extensive use of the Crow Canyon Environmental Archaeology Program comparative collection (Adams and Adams 1987) for comparison. I collected modern specimens near Sand Canyon in the summers of 2008 and 2009 and charred them to create my own comparative collection for the area. Compendium A and B (Adams and Murray 2004), as well the Crow Canyon herbarium voucher collection support my identifications. Identification standards conform to Adams and Murray (2004). I also consulted herbarium specimens from the University of Victoria Herbarium.

The Agriculture and Agri-Food Canada Kamloops Range Research Unit, Kamloops, British Columbia, kindly shared herbarium specimens with me.

Categorization of remains

I have included unknown (to date) botanical and non-botanical/other-type materials (charred or uncharred) to accommodate for the possibility that these may be identified in the future. In this way I did not need to make decisions about what would *not* be documented. Inasmuch as possible, this additional information reflects the actual richness of the sample and suggests a level of abundance of the various kinds of remains. It is an attempt at full coverage or 100 per cent survey of the SCP samples. Consequently, the study data reflect considerably more detail than is normal practice. To adapt from Minnis' (1987:123): given the clear challenges for the identification of many remains, including tissues and other "unknowns," it would be simple to avoid fragmented and less-than-ideal bits and pieces, but we lose information, most often information about fragmentation or ancient processing. While it may be prudent to focus energies elsewhere, it would be inappropriate in this study to ignore what often makes up the bulk of plant remains in light fraction samples. I heed the advice of Vorsila Bohrer, who said it best: "cultural and non-cultural factors represent two sides of the same coin—have we always examined each side with equal care?" (1986:33). I have left decisions of the value of including this information to others rather than arbitrarily discarding this "other side" of the coin.

All results are recorded either directly in chapters or in data tables found in various Appendices. Counts of individual taxon (abundance or density measures) however, are not the focus of the study or CCAC archaeobotanical investigations generally (Adams 2004:8). While counts may suggest a level of use, they may also represent the effects of good preservation, hardy morphology, or just plain serendipity. Counts are noted, however, to suggest a comparative degree of botanical, non-botanical or "other unknown" abundance or density, if deemed informative. These can reflect the number of sub-samples examined rather than represent true counts of quantity. In some cases, certain remains are so abundant that the notation ">" means that, at this point, the number of occurrences was high and did, or did not, warrant time spent counting.

Reporting: assumptions and documentation

Samples are assessed based on the goals for interpretation of the plant record as detailed in the Adams et al. (2007) report, focusing on the subsistence economy of SCP with a focus on food, fuel and other uses. The identification and analysis of construction materials was included in the original SCP goals but achieved through the recovery of vegetal samples, large pieces of wood and other materials clearly identified as structural (Adams et al. 2007). This assessment is not included here. Flotation samples yield smaller sized remains and the focus is on inferences of fuel, food and other uses as could be inferred from light fraction remains. No well-supported assessment of construction materials is possible in the context of flotation samples. I

Bulk volume samples (FV1-20)

I use an interpretative value model based on the goals of the original SCP archaeobotanical analysis as a method of evaluating sampling effectiveness. Two fundamental assumptions are made in the assignment of interpretative values for identified remains: 1) if the same scheme is applied to all data (new and previously recovered), a reasonable comparison of interpretative richness can be made; and, 2) as a plant or part may have more than one potential use, these are counted as unique. For instance, if both juniper wood and juniper berries are present, juniper is valuable to the interpretation of the deposit because it reflects two different use potentials, the use of juniper berries as a subsistence-related resource and the use of juniper wood as a fuel source. In such a case, juniper is given two use values. In addition, I do not lump species of pine under one category. The interpretation of pinyon pine as an overharvested resource impacted by drought in late 13th century Mesa Verde tells us that identification of pine species is critical to this debate. I count identifications of *Pinus* sp., *Pinus edulis* (pinyon), and *Pinus ponderosa* as separate values.

Species-area curves samples (SC1-10)

I assess species area curve samples on my findings from unexamined portions of the smallest screens (.71 mm and .25 mm particle size). The 1.4 mm portions are presumed previously examined as evidenced by the lack of labeled “unexamined” 1.4 mm materials for individual samples. Subsampling protocols for the 4.75 and 2.8 mm portion sizes are not evaluated, although in some cases, identifications from the smallest screen sizes provide information about the effectiveness of subsampling for charred wood in the larger screens (subsampling that is typically limited to the examination of 20 pieces of charred wood/charcoal). In these cases, charcoal I recovered in the smallest screens had not been previously identified in larger screens. The recovery of previously unreported wood hints at the structure and durability of specific wood types, ones that fracture and fragment. My results are compared on the basis of the number of new taxa recovered vs. the original findings and the potential for increased interpretative value with more volume analyzed.

I define three categories of materials. These categories have proven useful in assessing the SAC approach while accommodating for remains that may be identifiable by others. These categories are: “taxa,” “botanical,” and “non-botanical/other.” Specimens identified to the taxa-level are those charred botanical remains identified to botanical family, genus, or species. Botanical-level remains are those charred botanical bits and pieces that may, with more time or greater skill, be identifiable at a taxa-level. If not, they may *infer* a taxa-level identification. The specimens are morphologically distinct and, while they may represent parts of a single species, they may also represent the results of ancient processing activities and are considered unique information for the purposes of this study. These remains represent the bulk of botanical content of light fraction, those “less-than-ideal” fragments. Non-botanical/other-level remains encompass modern or uncharred non-plant material unless otherwise specified. The non-botanical/other category provides evidence such as disturbance indicators (insect and other disturbance evidence) and other unique remains not classified elsewhere that may contribute additional information. “Other” accounts for uncharred and remains that could be botanical. Categorizing the contents of the light fraction in this way reflects identification standards used in previous investigations and attempts to compensate for differences in the results and research approaches. If a specimen cannot be identified for this study, that does not mean it cannot be identified and have some interpretative value in another.

I made some assumptions with regard to the previous findings. At the time the samples were originally analyzed, light fraction specimens were not recorded by observation, screen capture and subsample number, nor were individual light fraction portion volume amounts available. To identify the screen in which a specimen may have been recovered originally, the specimen was re-screened. This “new” screen size is then accepted as the screen in which the specimen was likely recovered in the original analysis. The subsample number was calculated by counting by three consecutive subsamples to identify the point at which the previous analyst identified “asymptote.” In cases where it was not clear that any subsampling had occurred, an assumption was made that portion sizes were subsampled, no new taxa were observed, and the examined materials were returned to the portion volume and stored. The results from the previous study were not reviewed prior to the analysis. The portion sizes for the SC samples were examined one time only.

Flotation samples are typically assessed only by archaeobotanists but they are also repositories of non-botanical information. Researchers may be missing an opportunity to utilize these resources for studies in other specialties. Light fraction samples are a potential source of both natural and cultural factors in site formation and discard patterns, excavation and modern disturbance effects, in addition to ancient non-botanical human use. This is most evident in the SAC analysis where diversity of unknown botanicals and non-botanical/other-type remains are plotted along with identified taxa in accumulation curves to explore accumulation patterning.

Chapter summary

Archaeobotanical samples pose numerous limitations for assessing a methodology that relies on the capture of particular artifact types, the accurate measurement of volume, and the assessment of representative data. Other limiting factors such as degradation, excavation, and preservation issues are substantial for plant remains. The Sand Canyon Pueblo sample data are viewed from the standpoint that more samples or additional volume may enhance the understanding of Sand Canyon Pueblo deposits, potentially providing a more comprehensive and informative dataset. In the next chapter, I present a review of Sand Canyon Pueblo, its structure, history, and excavation. The context of samples is described in detail.

Chapter 6 Sand Canyon Pueblo

Chapter overview

To evaluate the effects of archaeobotanical sampling on interpretative potential, I revisited Sand Canyon Pueblo (SCP) through an analysis of the excavation and a synthetic reappraisal of the cultural content of the site. This chapter serves as a review and forms the background to my interpretation of the plant record and the cosmological content of the site. Here I summarize information from Crow Canyon Archaeological Center databases (CCAC 2004, 2015a), the archaeobotanical report (Adams et al. 2007) and the final site report (Kuckelman, ed., 2007). The unusual plant assemblage identified by Scott and Aasen (1985) provide evidence of specialized use of pharmacologically active plants that finds material correlates in block 100. The timing of sample deposition and the cultural "matrix" in which these resources were found allows for an enhanced understanding of the occupation. The material culture of Sand Canyon Pueblo and its potential for deeper insights into the occupation is supporting evidence of my case for clan organization and a medical toolkit. Electronic links to architectural plans are provided in this chapter.

Background

"That village sat looking down into the canyon with the calmness of eternity ... hidden away in this inaccessible mesa for centuries, preserved in the dry air and almost perpetual sunlight," writes novelist Willa Cather (1925:201, 202), perfectly capturing the Ancient Puebloan landscape of Mesa Verde. In 1994, a Puebloan participant at a Crow Canyon Archaeological Center consultation event echoes a similar but deeper and more personal sentiment,

> Even though people moved on, these places are sacred because people lived here and performed songs, prayers, and ceremonies here. We respect this and are awed by this (Thompson 2002:261).

We are indeed. This is Sand Canyon Pueblo, resonating in its humanity, tragedy, and abandonment. The events here reflect a catastrophic reconfiguration that reshaped the Ancient Pueblo world in the Mesa Verde region, setting it on a long and enduring march towards Pueblo culture as manifest today. Archaeologically, Sand Canyon Pueblo (SCP), site number 5MT765, is a village of stone and adobe consisting of towers, plazas, blocks of rooms and circular aboveground and subterranean kivas—architectural structures defined as household domiciles or community buildings.[28] It is situated at the

[28]Kuckelman (2000) describes the typical kivas found in the Mesa Verde area as roofed structures, usually circular and built at least partially underground. Accessed through a hatchway in the roof, they include design

head of a side canyon in Sand Canyon, Montezuma County, Southwestern Colorado near the contemporary town of Cortez. Dated to the late Pueblo III period, (A.D. 1150-1350), an archaeological era first described by Alfred Kidder in 1927, it is a period also known as “Great Pueblo,” or “the Great Period” (Adler 1996:1; Roberts 1935:32). And so it was. Pueblo III began with the decline of the complex regional socio-economic and political system that centered round Chaco Canyon in northern-central New Mexico. The Chaco period, typified by spectacular and elaborate stone architecture in the form of huge apartment-building style “Great Houses” is known for its extensive connecting roads and outlying settlements called Chacoan outliers. The Chaco period ended with the creation of new settlements, communities that Adler (1996:1-2) describes as “a Puebloan settlement geography that closely parallels that of the historic Pueblos,” a tangible link to the deep past. Sand Canyon Pueblo is one of these settlements. Like many post-Chacoan villages with reminiscent architecture, Sand Canyon Pueblo was significant for its size and fortification, built straddling a cliff and protected by a two-storied enclosing wall and defensive towers. And, similar to other large mesa-top village occupations in the Mesa Verde area, persisted only 20 to 40 years. Many, like SCP, abandoned after events of catastrophic violence (Stuart 2000:138-139). Based on tree-ring cutting dates, the people of Sand Canyon Pueblo lived and laboured there from the A.D. 1240s or 1250s until approximately A.D. 1280 (Kuckelman 2007b). The timing, patterning and scale of occupation similarly manifested throughout the Four Corners.

Originally unnamed, Sand Canyon Pueblo was first described by Prudden in 1903 (260-261). Some sixteen years later, Fewkes (1919), who described much of the earliest ethnobotany of the Hopi, referred to the site as Johnson Ruins. His interest lay in its D-shaped building (“block 1500”) that was hauntingly similar to his discovery of a structure he named the “Sun Temple” found in the sandstone cliffs of Mesa Verde (18). In 1984, Crow Canyon Archaeological Center (CCAC) researchers began the first of limited but intensive excavations at the site (Lipe and Kuckelman 2007:para.14-17). E. Charles Adams, Bruce Bradley, and a team from the Center surveyed Sand Canyon Pueblo and approximately 200 km^2 of surrounding area, which they renamed the Sand Canyon Locality (Lipe 1992:2; Figure 6.1, p. 129). Early investigations (Adams 1985a, 1985b, 1986; Bradley 1986; Bradley and Lipe 1990) led to long-term interdisciplinary study that included CCAC’s Site Testing Program, which focused on the excavation and analysis of thirteen smaller sites in the

elements such as roof supports (pilasters) built on an interior encircling bench. They contain a hearth (formally constructed, usually found thermally altered and use is associated with cooking, heat and/or light), a hearth deflector and a ventilation system. Thought to have evolved from earlier pithouse structures of the Basketmakers, historical and contemporary kivas are ceremonial chambers associated with particular Pueblo groups (Bahn 2001:237). Ethnographically, kivas serve as centers for the maintenance of secret and sacred knowledge and male ritual power (Mobley-Tanaka 1997:437).

Locality (Varien, ed.1999; Varien and Kuckelman 1999). Sand Canyon Pueblo is one of the two largest Pueblo III villages in this area and is now part of the Canyon of the Ancients National Monument under the stewardship of the United States Department of the Interior, Bureau of Land Management. As is the case for many ancient Southwestern sites, Sand Canyon Pueblo holds fascination for generations of scholars and visitors and a sacred place in the hearts of those who claim ancestry with the original inhabitants. True to author Willa Cather's description of Pueblo ruins that opens this chapter, it is impossible not to be awed by the scale and continuities of a "culture" revealed in architecture and artifacts, "hidden away but persisting," for centuries. This persistence can be seen in Pueblo cosmology today. Through my analysis of sampling and methods, Sand Canyon Pueblo archaeology provides a stunning backdrop for a deeper interpretation of the archaeobotanical record that highlights the cosmological content of the site and reinforces the importance of a synthetic approach to analysis for archaeology.

The archaeology

The archaeological data collected and analyzed by CCAC researchers has contributed much of what is known about 13th century occupation of Mesa Verde area villages. Initial goals for the Sand Canyon Pueblo excavations were to interpret the local and regional chronology, to understand the role of the pueblo in the greater community and in relation to the mass depopulation of the area that occurred in the late A.D. 1200s (Adams 1985a; Bradley 1992; Lipe and Kuckelman 2007). Sand Canyon Pueblo research has contributed to a large body of work focused on Pueblo III times, a small sample of which includes investigations into climatic and agricultural modeling (van West 1994, 1996; van West and Dean 2000; van West and Lipe 1992), historical ecology (Varien et al. 2007) and community organization (Adler 1990, Adler, ed. 1996; Adler and Varien 1994; Huber 1993; Ortman 1998; Ortman and Bradley 2002; Varien et al. 1996). A number of studies have examined the archaeobotanical and archaeofaunal records (Adams and Bowyer 2002; Driver 2002; Duff et al. 2010; Gish 1990; Muir 1999, 2007; Scott and Aasen 1985). Research also includes interpretations of social relationships and the violence that so catastrophically left its mark in the region at the end of the 13th century (Kenzle 1997; Kuckelman et al. 2002; LeBlanc 1999). CCAC investigations into the settlement ecology and community organization are addressed through excavation at the Goodman Point Pueblo, another large Pueblo III village located nearby (Coffey and Copeland 2011).

Situated at an elevation of 2073 metres, Sand Canyon Pueblo was built around the head of a side canyon that is part of the larger canyon system that cuts through the McElmo Dome. Like Mesa Verde, McElmo Dome is a massive limestone uplift but one that is of considerably less elevation. A permanent spring drains into the canyon at McElmo Creek (Gish 1990:11). The site covers approximately 2 hectares (estimated at 5.42 acres) and is thought to consist of 420 rooms, 90 kivas, 14 towers, an enclosed plaza and two large public buildings—a D-shaped, bi-walled building and a "great kiva"[29] (Bradley 1992). Adler and Wilshusen (1990:138) note that great kivas are examples of early monumental architecture that appeared on the landscape of the Four Corners in late Basketmaker times. The great kiva at SCP is an example based on its size and architectural elements. Rooms surround the majority of its periphery. Although the SCP great kiva appeared to have had no roof, four large roof supports are present, the peripheral rooms providing a barrier between the kiva and the outside.

Barriers are a theme at Sand Canyon Pueblo. A two-storied wall encloses much of the site, at least partially encircling a fresh water spring and giving the impression, if not the reality, of a protected domestic water supply within the bounds of the village (LeBlanc 1999). Divided around the drainage at the central northern portion, the canyon bisects the village into east and west halves. Some of the buildings hang below the cliff face, clinging to the slopes at the southern end that are best visualized in an artist's reconstruction (Figure 6.2, p. 131). An estimated 400-600 people lived here in what became a single brief occupation spanning approximately 30 years (Kuckelman 2007a). So at odds with the complexity of the architecture and the clear indication of a planned and executed "permanency," at some point after A.D. 1277 the people left or perished, some leaving behind treasured belongings. The apparent violent death of many was a tragic end to what appeared to be a functioning, although fearful, agricultural community, the residents of which, based on human remains, were relatively healthy, average to above-average in stature for the time and heavily reliant on a diet of maize (Kuckelman 2007b: para. 36). The defensive architecture of Sand Canyon Pueblo, the inferred changing subsistence strategies (Adams et al. 2007), the evidence of at least one violent encounter and severe prolonged regional drought (Douglass 1929), suggest that there were multiple stressors that contributed to the depopulation of the village, and, the mass migration of people from the Mesa Verde area. A map of the area identifies Sand Canyon Pueblo and the Sand Canyon Locality (Figure 6.1, over).

[29] Great kivas are freestanding large, community-sized kiva structures. Wilshusen (1999:174) records evidence of great kivas in the southern half of the San Juan River drainage basin as early as Basketmaker III (A.D. 500-750). Great kivas are found through the Pueblo II period (A.D. 900-1150) and in Pueblo III (A.D. 1150-1300) associated with large apartment-style villages (Lipe and Varien 1999a, 1999b). They are typically interpreted as structures of ritual importance that served to aid in community cohesion. The prime example is the massive freestanding Chacoan era, Casa Rinconada great kiva of Chaco Canyon, New Mexico.

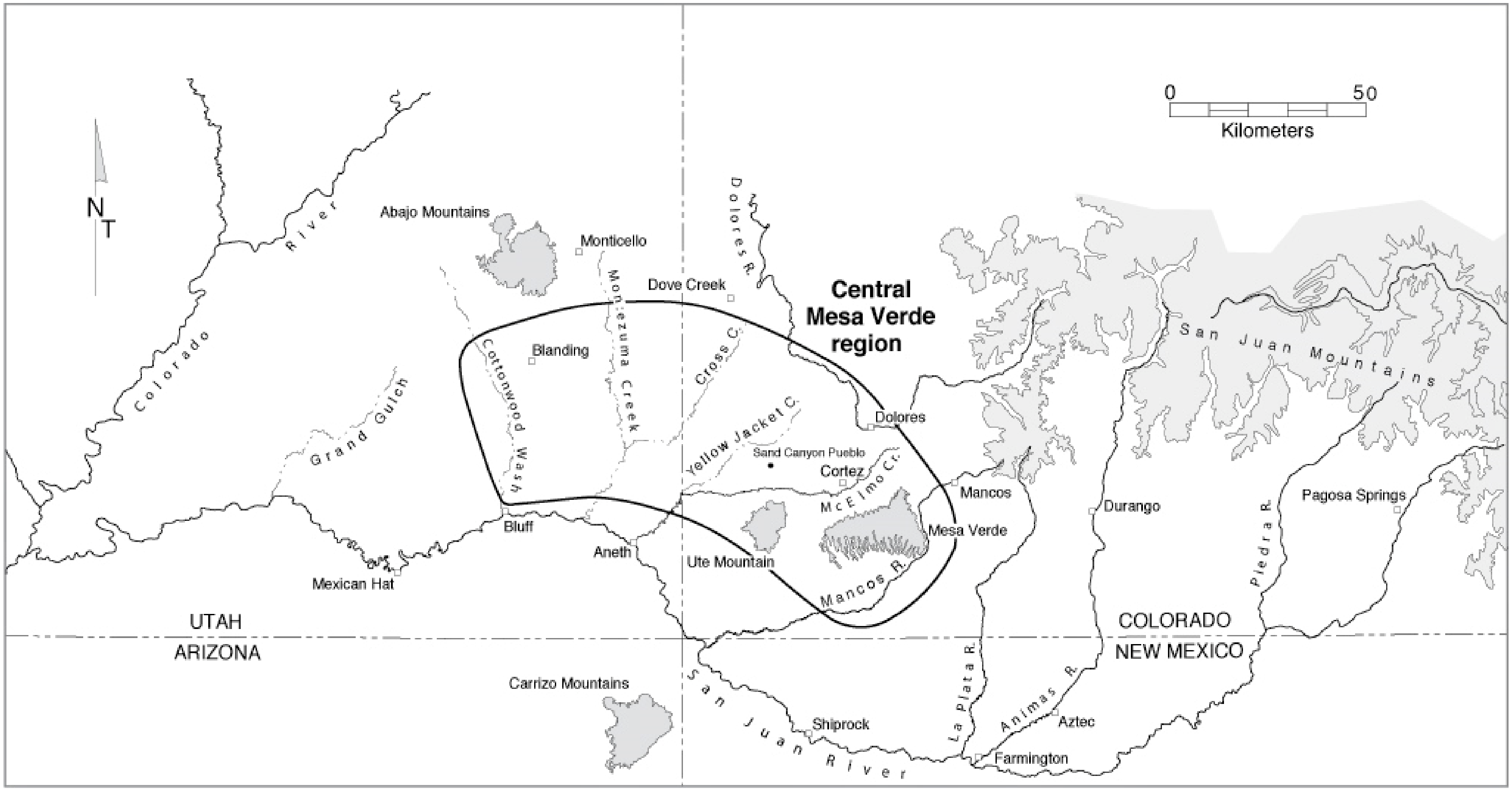

Figure 6.1 The Central Mesa Verde Region featuring Sand Canyon Pueblo and Sand Canyon Locality (Courtesy of Crown Canyon Archaeological Center).

Environmental setting

Adams et al. (2007) and Adams and Petersen (1999) provide a detailed evaluation of the botanical environment for Sand Canyon Pueblo and the surrounding region, much of which is reiterated in this section.

Sand Canyon Pueblo resides in an area of Great Basin Desertscrub (Turner 1982), a community dominated by *Artemisia tridentata* (big sagebrush), *Atriplex* (saltbush), *Chrysothamnus* (rabbitbrush) and *Ceratoides* (winterfat) and found between 1200 and 2200 metres elevation (Adams and Petersen 1999:14). These shrubs can be seen in abundance on the mesa top surrounding the village today. Other major species associated with this group include *Opuntia* (prickly pear cactus), *Echinocereus* (hedgehog cactus), and a variety of grasses, *Achnatherum/Stipa/Oryzopsis* (ricegrass/needlegrass-types), *Bouteloua* (grama), *Sporobolus* (dropseed), *Hilaria* (galleta) and *Poa* (fendlergrass)(14-16). Introduced Eurasian weedy annuals also populate the area (14). Above 1500 metres (to 2300 m elevation) are found Great Basin Conifer Woodland species (Brown 1982), a pinyon-juniper community consisting of a variety of juniper species (*Juniperus scopulorum, J. osteosperma*, and *J. monosperma*) and *Pinus edulis* (pinyon pine). This community includes shrubby plants such as *Purshia* (bitterbrush/cliff-rose), *Fendlera* (fendlerbush), *Cercocarpus* (mountain mahogany), *Peraphyllum ramosissimum* (peraphyllum/wild crab apple), *Rhus aromatica* (skunkbush/lemonadeberry), *Amelanchier* (serviceberry), and *Lycium pallidum* (pale wolfberry)(Adams and Petersen 1999:16). Similar to Desertscrub communities, grasses include such species as *Achnatherum/Stipa/Oryzopsis hymenoides* (Indian ricegrass), *Agropyron smithii* (western wheatgrass), *Sporobolus* and *Koeleria* (Junegrass)(16). *Yucca baccata* (Datil yucca) is prevalent.

Along the canyon rim, *Ephedra viridis* (Mormon tea) infiltrates the rocks and cliff surrounding the village (Adams 1993a:10; personal observation, June 2009). Shrubby taxa such as *Populus* (cottonwood) and *Salix* (willow) are present in the area. Scott and Aasen (1985:1) report a small riparian community composed of *Carex* (sedges) and *Typha* (cattail) at the site. Gish (1990:11) documents *Juncus balticus* (wirerush) at the same location. At elevations between 2000 and 3050 metres at Ute Mountain, *Pinus ponderosa* (ponderosa pine) and *Pseudotsuga menziesii* (Douglas-fir) are found today. Associated shrubs include *Quercus gambelii* (Gambel's oak) and berry-producing species such as *Ribes* (currant), *Rosa* (rose) and *Sambucus* (elderberry) species (Adams and Petersen 1999:17), many of these shrubs are found around the site today.

Agricultural modeling investigations by van West (1994:144, 1996:233) indicate that the area around Sand Canyon was at one time productive and predictable for farming and capable of supporting many thousands of people. Agriculturally productive soils are the result of deep windblow silts contributing to the success of farming today (Arrhenius and Bonatti 1965). In addition, major precipitation events critical for the growing season include winter snowfall and summer monsoon rains (Erdman et al. 1969:19). The summer rains come at a particularly precarious time in terms of water deficits that historically occur in July and August. Around A.D. 1275/76, prolonged drought and unstable seasonal weather patterns can be seen in the tree-ring record. This trend persisted long term (Douglass 1929). Such conditions no doubt contributed resource challenges. When combined with a village population that could have exceeded carrying capacity and contributed to a depleted natural resource base, Sand Canyon Pueblo likely played a role, whether active or passive, in the mass movement of people out of the Mesa Verde region at the end of the 13th century (Adams and Bowyer 2002; Dean and van West 2002; van West 1996). As for climatic disturbance, the timing of the monsoons today also appear to me to be shifting, coming early in 2008 and 2009. The consequences of seasonal weather changes as key catalysts for resource stress in the past serve as warnings of food security problems in the future. The archaeological record of Sand Canyon Pueblo offers cautionary evidence for present-day challenges.

Initial research goals and sampling strategies for Sand Canyon Pueblo excavations

Fourteen “architectural blocks” (blocks 100-1400), defined as “clusters of contiguous structures” (Kuckelman 2000), are identified for Sand Canyon Pueblo; most perimeter rooms within these blocks are clearly confined by the two-storey encircling wall (Bradley 1992; CCAC 2004). CCAC’s excavation focused on intensive study of identified architectural blocks and partial trenching of individual kivas and spaces. Initial research questions focused on an original supposition that Sand Canyon Pueblo served solely as a ritual center to investigations of environmental stress, the structure of the wider community, and the role the pueblo played during a time of widespread social upheaval. The final SCP report summarizing all previous investigations was published in 2007, synthesized and edited by Kristin A. Kuckelman. The extent of excavation is detailed in an early site map (Figure 6.3, p. 132). Glenn Felch’s artistic reconstruction of Sand Canyon Pueblo (Figure 6.2, over) paints a picture of a complex and well-ordered village perched on a cliff face and bounded by a significant enclosing wall. The structure located in the middle left of the frame is the D-shaped building (block 1500).

Four general sampling strategies were used during the excavations (paraphrased from Kuckelman et al. 2007: para.4-6):

1) Intensive excavation of selected kivas (household-level domiciles) and their associated rooms, known as “kiva suites.”

Figure 6.2 Sand Canyon Pueblo reconstructed. Painting by Glenn Felch (no date known), photograph J. van Roggen, recoloured (courtesy of Crow Canyon Archaeological Center). The top of the photograph is oriented north-northeast.

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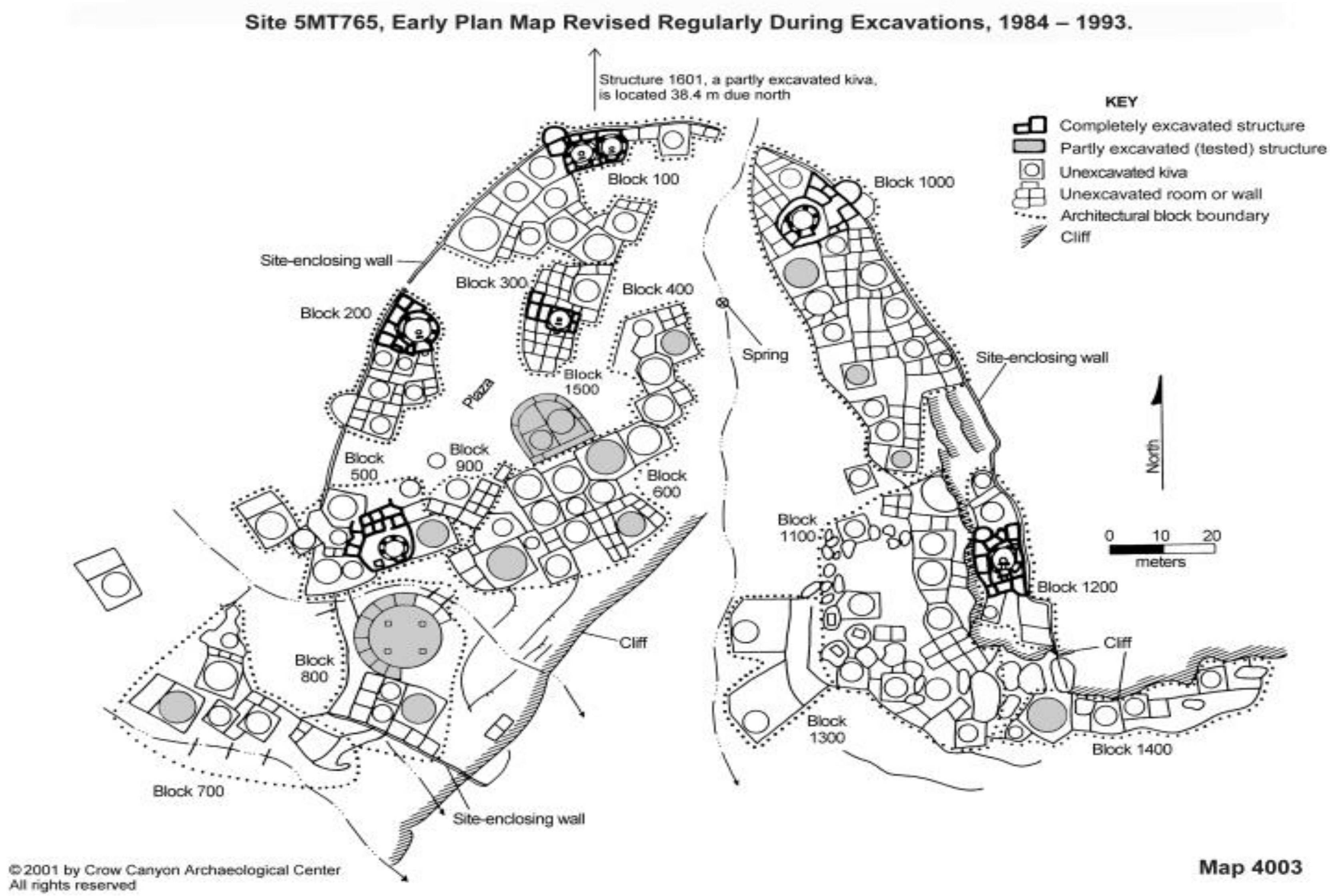

Figure 6.3 Site 5MT765: Early Plan Map Revised Regularly During Excavations, 1984-1993 (courtesy of Crow Canyon Archaeological Center).

2) The test excavation of selected individual kivas (trenches).
3) The test excavation of buildings suspected of being public architecture or community architecture (the great kiva and D-shaped building).
4) Excavation of stratified random ("probability") sampling units in non-architectural areas. These consisted of the random selection of 2-x-2-m test pits excavated within defined areas; that is, those areas containing no structures of any kind.

The sampling strategy for archaeobotanical samples emphasized the surface collection of macroremains or macrofossils (large plant remains hand-picked from sediments), standardized one-litre flotation samples and pollen samples. A variety of control samples were also collected (Adams et al. 2007: para.1). The archaeobotanical goals concentrated on summation and interpretation of the role of plant resources in the subsistence economy of the pueblo through an analysis, in the case of flotation samples, of food, fuel and other uses in an effort to detect patterns that might illuminate subsistence strategies, resource availability and differential use of plants in public and private buildings (para. 1). Sampling contexts included thermal features, such as hearths, firepits[30] and burned spots,[31] and deposits of refuse (formal middens and other trash accumulations). Because of difficulty in anchoring clearly defined temporal deposition, four general time frames were proposed to assess change in plant use through time categorized as earliest, early, late, and latest occupation deposition. Many tree-ring dates help anchor specific time frames. While seemingly obvious, the "late" occupation category relates to samples in contexts supported by tree-ring dates ending in "latest" occupation events—the final violence that caused the death of residents and depopulation of the village. Those who survived the catastrophe fled, perhaps to return later to burn kiva roofs and "close" the village. Perhaps their aggressors remained for a time. Samples from deposits that show clear association with violence or re-use episodes, however brief, are considered samples from an "abandonment context" or "post-abandonment" time frame, the terms capturing a finality of deposition or "latest." Earliest and early categorizations relate to building episodes, construction sequences and stratigraphy (sterile and overlaying deposits) and assessment of tree-ring dates when available. These temporal categories replaced earlier assessments of an "abandoned leisurely/abandoned violently" dichotomy used in some cases for understanding room and kiva use,

[30] Firepits are usually basin-shaped and localized burning occurred. Construction of firepits is expedient and minimal (CCAC 2001:24).

[31] Burned spots are defined as areas of localized fire reddening and/or charring on a surface. They show no evidence of deliberate construction and may be accompanied by an accumulation of ash and/or charcoal on the surface or by soot blackening on a wall face above the surface (CCAC 2001:23).

tied to lack of useable items and those with clear evidence of carelessly deposited and traumatically injured human remains. Although such categories allow us to think about archaeological time and keep our focus on the human component they are not that helpful in assessing a change in plant use where the problem of what qualifies as a specific time frame may be distorted.

Whether drought played a significant role in the depopulation of Sand Canyon Pueblo can be better explored through comparison of early/earliest (even middle occupation) deposits to that of later deposits. However, temporal designations are not so easily made for individual samples and a short occupation with a challenging depositional history. To more fully understand the effects of sampling on interpretative potential I synthesize data from the SCP database (CCAC 2004), maps, provenience and feature reports provided to me by CCAC, the final report (Kuckelman ed. 2007) and, rely in particular, chapters from Kuckelman (2007a, 2007b) in an effort to more firmly anchor sample deposition. The challenges in doing so are many. Some excavation units did not yield tree-ring dates. Some tree-ring samples came from re-used wood or firewood rather than construction beams. Many of the buildings were built on bedrock making stratigraphic placement difficult to assess. Surfaces on bedrock could be "old" or "new," the use of structures taking on new purposes not clearly visible as different. The entire occupation "collapsed" in a "latest" time frame due to a catastrophic warfare event although it is probable that some residents left earlier based on sediment accumulations and dismantled buildings. As for the plant record, we may see a decrease in plant use reflecting a declining population for reasons other than lack of food or other resource shortfalls. In addition, not all flotation samples recovered were evaluated and most were subsampled. The plant record within these constraints will not be comprehensive. It is, however, robust enough to suggest new interpretations.

Setting the stage for alternative explanations

The architecture of the village, from its small "ordinary-sized" domestic kivas, to special-purpose buildings, such as the great kiva (the larger, grander, community-sized structure) and the D-shaped bi-walled building are of particular importance for their private, public and ceremonial potential. The construction sequences are critical for speculating on social behaviour and change. The D-shaped building, so reminiscent of Fewkes' Sun Temple, is compelling for its design, seemingly representing links to ideologies associated with the D-shaped architecture of Pueblo Bonito in Chaco Canyon. Ortman and Bradley (2002:73) describe Sand Canyon Pueblo as evidence of a symbolic revival linked to Chaco Canyon.

> A new style of imaging the community ... echoes of Chacoan architectural symbolism in the shape of the enclosing wall, the analogous shape and interconnected perimeter rooms of the D-shaped building, and the A.D. 1200s reuse of great house sites

> constructed during the heyday of the Chacoan phenomenon ... a reinvention of a Chacoan tradition.

This reinvention results in the evolution of the social landscape. In this respect, Sand Canyon Pueblo may have played a role in the disorder simply by association. The presence of genetically related individuals suggests a continuity of ancestry with Pueblo Bonito (Kuckelman and Martin 2007). Kuckelman (2007b: para.23) suggests that the D-shaped building could "signify an early 'Bow' warrior society or priesthood." On re-analysis of the evidence it is apparent that a group associated with the metaphor of the "D" held an important role, enough to be acclaimed through architecture in the A.D. 1260s–1270s. The apparent shift in use of large, seemingly important ceremonial buildings in the late A.D. 1270s indicates a symbolism that lost its power. The D-shaped building becomes desacralized and used for mundane purposes, the original internal features of ritual importance sealed over. The dedicated mealing rooms[32] with their multiple metate bins (grinding stones in stone bins) are no longer visible in the great kiva or in block 1200. In the D-shaped building, metate bins are moved into places that previously had none, the moving metate bins and patterns of discard thus proof of transition. Whatever the catalyst, it was unsettling. When viewed as a transformation of sacred to mundane, or a more telling categorization, special places transformed by a kind of "pollution" (Douglas 1966) we know the shift was ideological.

The Sand Canyon people clearly categorized their refuse and their communal spaces differently late in the occupation. Douglas' (1966:2) assertion that "dirt is essentially disorder,"

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[32] Mealing rooms are interpreted as food-processing areas where corn or other grains or vegetal material is ground. Artifacts associated with this room designation are metate bins (stone lined bins with stone slab bases for grinding and catching flour or meal) and grinding implements such as hand-held grinding stones (manos). Mobley-Tanaka (1997:446) argues that mealing rooms are important in pre-Pueblo III Anasazi society in terms of the maintenance of social integration through complementary gender roles, the male role dominating in the kiva and social ceremony, the female role played out in the mealing rooms. The shifts from subterranean mealing rooms to surface mealing r0ooms in Pueblo III may represent the development of more highly ritualized space of the kiva, seen in structural elaboration. Mealing rooms become more "peripheralized" (446). Mobley-Tanaka suggests the shift may represent "women becom[ing] the deemphasized producers for ceremonies, as access to ritual knowledge is restricted to men through kiva association" (1997:446). Young (1987) reiterates these roles in the kivas and ceremonials of the Western Pueblos. Mealing rooms and kivas are gendered but also serve as teaching spaces where reinforcement of kinship, role and ideology is passed down through generations. The mealing room, metate and mano are transformative, elaborated by costume, robe, hair whorls and role in historic ethnographies, the production and transformation of "corn" into meal in three parts—a first, second and third processing to finer and finer powder (Cushing 1920; Kennard 1979). This process is acted out in contemporary ceremony in the plaza by men disguised as, and transformed into, women on the Hopi mesas (personal observation 2009); the hypnotic sound of "grinding corn" echoing throughout the plaza is accompanied by the rhythms of elaborately costumed dancers. The archaeobotanical evidence of SCP mealing rooms hints the work of women and the deeper meanings of Sand Canyon life. In the movement of metates from mundane to sacred spaces and the burial of mealing rooms in trash, we see a transformation of ideology, one that reflects an adaptive strategy to something more unsettling than environmental stressors for people accustomed to difficult conditions.

seemingly fits with the pattern of later activity, with “refuse out of place” as a metaphor for, and proof of, such offense. Whiteley (1998:130) writes,

> Clifford Geertz’s general view—that culture is a system of symbols with shared meanings—will suffice. Transformative cultural changes should, then, reorient, refigure, or otherwise significantly alter existing structures of cultural symbols and their social correlates. ‘Religious’ symbols, and here I follow Geertz’s specific definition (1966:4), are particularly powerful concentrations of cultural attention; major changes to central religious symbols will have correspondingly powerful effects in other dimensions of the sociocultural order.

“Disorder” and transformative reconfigurations are apt, although muted, descriptions of the A.D. 1270s at SCP. After so much work was accomplished to create and embellish a community “order” in village plan and, presumably an accompanying social and ceremonial cycle, something(s) or some person(s) reconfigured what was either “SCP normality” or a drive towards normalcy. It is compelling to view the human remains as part of a deliberate, planned, individually specific and, without doubt, final reconfiguration. Of the 32-33 people who could be described by sex, age or life stage inadvertently encountered during excavation, half were found in catastrophic contexts in blocks 100 and 1000. These are gateway blocks, surrounding the head of the canyon, each protecting the northernmost flanks of the village to the east and west. Many of the individuals who perished here showed evidence of relatedness within and between the blocks. Their remains displayed a variety of skeletal abnormalities that certainly suggests a shared history (Kuckelman and Martin 2007). In at least one case, devastating health conditions may well explain the presence of unique plant remains found in various latest occupation deposits.

The floral and faunal records, data of a life lived through “subsistence,” not unconnected from the greater realities of social and ideological context, provide evidence of how refuse and disorder played out, most tellingly in the transitions and individual catastrophes that so marked the final days. Both records represent some measure of cuisine (a “sampled” cuisine) through accidental and deliberate discard. Similar to the constricted view of “abandonment,” cuisine and subsistence embodies much more than merely “food” or a “food economy.” The remains reflect complex cultural knowledge and practice that is dictated by cultural space, technology, rules, roles, obligations and a grammar to explain it all. Plants mitigate disease and dis-ease, the distinction of food and health blurred. Food cures hunger and the act of consumption also cures disease. Illness, deformity, incapacity and clearly painful living, conditions that indicate a definitive need for medical mitigation, mark the human remains of blocks 100 and 1000. Plants with medicinal properties should dominate the plant record in these settings based on skeletal evidence alone. In the analysis that follows, they do. The male in block 100 provides the key to unlock something of the greater realities of being human at Sand Canyon Pueblo.

The devastating presence of fatally injured human remains and the destruction of possessions allow for clear connections with time as an actual date—circa A.D. 1277, or shortly thereafter—based on a latest tree-ring cutting date.[33] Without reasonably definitive time frames, comparative analysis of resource change, stress, abundance etc., are unlikely to be well supported. In this respect, the greatest challenge for the interpretation of sampling effects and inferences of plant use at Sand Canyon is, in fact, "depositional time."

Categorizing SCP time: anchoring sample sequences using a five-phase approach

The archaeobotanical goals for Sand Canyon Pueblo analysis were, and continue to be, to document a representative picture of plant use by recovering as many and as varied plant remains as possible through managed sampling effort using standardized subsampling (Adams 2004). As for sample adequacy to achieve those ends, the effects of the one-litre and subsampling strategies require comparable time-centered activities to be meaningful. Compounding the various ambiguities associated with timing, the record for the site as a whole must be understood to assess whether additional volume produces data that can offer new insights. This is crucial, since simply comparing the results of a few samples for species counts produces another version of sample bias. In this next section, I describe the timing of sample deposition from the perspective of a plausible Sand Canyon cultural context. The objective is to anchor SCP within a legitimate behavioural sequence based on the evidence collected by CCAC researchers. This approach segregates the occupation of Sand Canyon Pueblo into five well-supported behavioural periods:

1) Earliest construction and initial occupation of Sand Canyon Pueblo as mapped.
2) An early ideological phase that takes into account construction of communal buildings and what must be a planned vision for Sand Canyon Pueblo.
3) An ideologically expansive phase that includes the construction of additional complexity in public architecture.
4) A transitional period where shifts in the use of public spaces appears to change.
5) Catastrophic and post-catastrophic behaviour as a result of a warfare event.

[33] Cutting dates reflect the actual year a tree died. Samples with cutting dates have bark (indicated by the letter "B" following the growth ring year) or continuous outermost growth rings around the available circumference (indicated by the letter "r"). A tree-ring year that is followed by the suffix "v" is considered near enough to the year the tree died to be considered a cutting date. Readers are referred to the 2007 report for additional detail. I limit my discussion to those dates recorded in stem and leaf analysis (Kuckelman et al. 2007) and do not use these suffixes here. The date range for the occupation of Sand Canyon Pueblo is inferred through tree-ring cutting dates (CCAC 2004; Kuckelman et al. 2007).

Each phase or period is tied to tree-ring cutting dates and building sequences, relative stratigraphy and artifactual evidence (Kuckelman 2007)(Table 6.1). I have highlighted those I estimate are reasonable. structures. Clusters of older cutting dates may indicate that beams were repurposed from earlier construction on the site or nearby (Table 6.1).

Table 6.1 Sand Canyon Pueblo tree-ring cutting dates by architectural unit. Number of tree-ring samples in brackets; my inferences rely on highlighted dates (adapted from Kuckelman ed. 2007).

Unit	Architectural type	Earliest cutting date	Latest cutting date	Other cutting dates
102	Aboveground circular kiva (fully excavated)	A.D. 1232 (1)	A.D. 1274 (2)	A.D. 1235 (15) A.D. 1250 (5) A.D. 1251 (4) A.D. 1271 (2) A.D. 1274 (2)
208	Aboveground kiva remodeled from existing tower (structure 212) (fully excavated)	-	A.D. 1244 (1)	-
400	Kiva, type unknown (partial excavation, trench only)	-	A.D. 1265 (1)	-
501	Subterranean kiva (fully excavated)	A.D. 1200 (1)	A.D. 1252 (2)	A.D. 1203 (24) A.D. 1220-1225 (7) A.D. 1250-1252 (17)
600	Kiva, type unknown (partial excavation, trench only)	A.D. 1235 (1)	A.D. 1266 (1)	A.D. 1241 (3)
602	Kiva, type unknown (partial excavation, trench only)	A.D. 1244 (1)	A.D. 1248 (1)	-
808	Aboveground kiva (partial (excavation, approximately half)	-	A.D. 1257 (2)	-
815	Aboveground kiva (partial excavation, trench only)	-	A.D. 1269 (1)	-
1000	Courtyard in block 1000 (fully excavated)	-	A.D. 1266 (1)	-
1004	Aboveground kiva 1004 (fully excavated)	A.D. 1228 (1)	A.D. 1266 (1)	A.D. 1240-1249 (7) A.D. 1250-1251 (5) A.D. 1260-1266 (10)
1013	Kiva, type unknown (partial excavation, trench only)	A.D. 1201 (1)	A.D. 1261 (1)	- -
1205	Room (fully excavated)	A.D. 1231(1)	A.D. 1260 (2)	A.D. 1231 (1) A.D. 1249 (1) A.D. 1251 (1)
1206	Aboveground kiva (fully excavated)	A.D. 1241(2)	A.D. 1262 (13)	A.D. 1242 (27) A.D. 1261 (3)
1218	Fill above corner rooms associated with kiva 1206	-	A.D. 1242 (1)	-
1219	Kiva corner room (fully excavated)	A.D. 1262 (2)	A.D. 1265 (1)	-

continued...

Table 6.1 Sand Canyon Pueblo tree-ring cutting dates in years A.D., by architectural unit continued.

Unit	Architectural type	Earliest cutting date	Latest cutting date	Other cutting dates
501	D-shaped building east kiva (partial excavation, west half of building)	A.D. 1202 (1)	A.D. 1261 (19)	A.D. 1210 (3) A.D. 1230s (3) A.D. 1240s (5) A.D. 1250s (7) A.D. 1240s (5) A.D. 1260 (3) A.D. 1250s (6)
502	D-shaped building west kiva (partial excavation, east half of building)	A.D. 1201 (1)	A.D. 1270 (1)	A.D. 1200s (10) A.D. 1210s (10) A.D. 1220 (6)
501	D-shaped building east kiva (partial excavation, west half of building)	A.D. 1210 (3)	A.D. 1261 (19)	A.D. 1230s (3) A.D. 1240s (5) A.D. 1250s (6)
502	D-shaped building west kiva (partial excavation, east half of building)	A.D. 1201 (1)	A.D. 1270 (1)	A.D. 1200s (10) A.D. 1210s (10) A.D. 1220 (6) A.D. 1248 (1)
503	D-shaped building peripheral room	A.D. 1198 (1)	A.D. 1260 (1)	A.D. 1199 (1)
506	East side midden, D-shaped building	-	A.D. 1252 (1)	-
511	D-shaped building peripheral room	-	A.D. 1262 (1)	-
519	D-shaped building west kiva 1502 lower storey “storage” room	A.D. 1202 (1)	A.D. 1218 (1)	A.D. 1259 (1) non-cutting date
521	D-shaped building east kiva 1501 corner room	A.D. 1260 (1)	A.D. 1261 (1)	-
527	D-shaped building west kiva 1502 upper storey “storage room”	-	A.D. 1214 (1)	-

Dates are problematic for numerous reasons, one being partial excavation. Many buildings did not yield wood beams with cutting dates. In other cases, timing is based on associated The nature of a 30-year occupation is that timing is more critical to assessments of food and discard than sites with deeper time depth. The ability to generalize is weaker in shallow deposits because what we have is evidence of hours and days of use, not a general economy as seen in years or decades, or at least ones that are clearly visible in the stratigraphy. Because of drought, the “Great Drought” marked by tree-ring records at A.D. 1276 (Douglass 1929), it is inferred that drastic environmental change caused wide spread subsistence stress in the Mesa Verde region and contributed to the use of unusual or perhaps non-preferred plant types (Adams et al. 2007). The skeletal remains of big game animals, such as deer and mountain sheep in the final days or weeks has been interpreted as evidence of typical distribution of meat, discard of bones and feasting analogous to historic Pueblo fall season food procurement, ceremony and discard management (Driver 2002; Muir 1999; 2007). My findings supports this contention. Alternatively, others see a new reliance on hunting big game, an inferred hunter-gatherer strategy when combined with the apparent absence of maize, signaling a subsistence stress response (Kuckelman 2007b). The less visible maize in these contexts can be attributed to a variety of causes such as sampling bias, pre-harvest or raiding for supplies. If other conditions, such as the social environment, played a greater role in the collapse of the occupation we may see differences in food access between groups. Key to these inferences is the content and context of deposits that accumulated after the onset of drought in A.D. 1276 in comparison with deposits that accumulated before that time. In the analysis to follow alternative explanations contribute to a continuing dialogue of cause-and-effect.

Following Ortman and Bradley (2002), I defer to earlier clustered dates, those in the A.D. 1240s and 1250s for initial construction. I use well-defined temporal sequences and group them by key events and phases of occupation clearly evidence by the archaeology (Table 6.2). Temporal categories as noted in Adams et al. (2007) are reevaluated within my five-phase behavioural scheme to allow for comparison between samples. My assessment may differ. I interpret the larger social context of occupation based on these dates and events through the following lens:

1) The village was built or evolved to mitigate threat. Initial construction probably occurred around the A.D. 1240s (Ortman and Bradley 2002). What is clear is that SCP was, at some point, conceived of as a large and imposing village but whether it began that way is uncertain.
2) The early period included artistic imagery incorporated into construction. This phase seemed to be followed by attempts to reinforce a Sand Canyon Pueblo "identity" with the design and beginning building phases of the great kiva. Some architectural blocks contain structures with ancestral design. Kiva 108 in block 100 has 4-pilaster kiva construction more often associated with Pueblo II. The kiva (501) in block 500 is subterranean, a Basketmaker configuration not typical Pueblo III. These may harken back to earlier times, perhaps to perceived "safer" times or functioned as ideological metaphor.
3) An expansion of ideological import seems evidence in the addition of peripheral rooms around the great kiva. The peripheral rooms were built on existing and finished outside walls hinting that more was required for the function of the great kiva. The barriers provided by peripheral rooms hint at a highly controlled space.
4) After some period of time, a social reconfiguration took place. This can be seen in the deliberate and sometime elaborate blocking of entryways that, although common enough occurrences through time, may be tied to what became a major

transition in how metaphorically important places were conceptualized and used. Evidence of this can be seen in changing behaviour such as trash accumulating in unlikely and presumably previously important or sacred places. Disorder can be inferred in the changing use and presumably shifting priorities of the D-shaped building and the great kiva, repurposed mealing rooms and deliberate introduction of metate bins to unexpected places.

5) At least one catastrophic attack from outsiders at the end of the A.D. 1270s caused the death, callous deposition and scatter of traumatized human remains. Possible breaches in the defensive architecture (block 200), the scale of violence and its aftermath proving the turning point for Sand Canyon Pueblo and, similarly, other villages in the region at around the same time. At SCP these events were followed by an apparent brief period of residency by attackers or revisiting by survivors. This is evident in ephemeral re-use of buildings and spaces.

Beginning in what may well have been the early years of construction and occupation of SCP, I consider contextual clues for expectations of the plant record in the A.D. 1240s.

<u>Circa A.D. 1240: initial construction and occupation of Sand Canyon Pueblo</u>

The reasoning and inference potential for this stage is founded on the A.D. 1240s as the most plausible decade for initiation of village construction based on the side as excavated. Only three structures have estimates of construction in this decade, kiva 600, kiva 602 and kiva 1400. All were partially excavated using test trenching. The overall configuration of SCP clearly indicates that its layout was conceived as a large, ideologically rich and presumably influential village, at least at some point in its evolution. The remodeling and building that occurred in the A.D. 1240s and early 1250s represents the first phases of a development of a Sand Canyon Pueblo identity that borrowed from centuries past as proposed by Ortman and Bradley (2002). With its apparent Chacoan symbolism—the D-shaped site-enclosing wall and D-shaped building resonating with Pueblo Bonito—and massive protecting wall, Sand Canyon Pueblo makes a potent statement, sending a message of capability, mastery and authority. Assuming, then, that the construction and remodeling events seen in this early decade represent the initiation of such a vision, the initial construction of block 100 with its estimated date of A.D. 1250 for the D-shaped tower (101), was part of a planned strategy to create something visually stunning.

The impetus for the building of Sand Canyon Pueblo clearly included concerns over safety and security. Abundance and variety of plant resources should be associated with the first decade of occupation for two main reasons: to feed an active labour force and to justify the elaborate construction. The area around Mesa Verde had to have been attractive for its ecological potential: the conditions needed for an abundant or, at minimum, more than adequate subsistence base than previous locations. Certainly it would have been adequate enough for people to continue to occupy the region if the residents were local and to attract new residents from further afield. There is little to indicate that people thought that drought would make continued presence in the area untenable. We should expect to see evidence of food plants that include wild and domesticated resources for a growing population, one that may well have celebrated the freedom that came with a large gathering of people working toward common goals. Table 6.2 outlines key features.

Table 6.2 Social context of the A.D. 1240s: earliest years of occupation?

Initial construction and occupation **estimated decade: circa A.D. 1240s** previously classified as "earliest"
Building sequences based on tree-ring dates (A.D.) (from CCAC 2004; Kuckelman et al. 2007:Table 3):[a] • Kiva 600 may have been built in 1241. • Kiva 1400 is tentatively estimated at 1245. • Kiva 602 estimated at or before 1248. • Midden accumulation under the courtyard (nonstructure 513) in block 500 pre-date the construction of the block estimated based on tree-ring cutting dates as initiated circa A.D. 1252.
Expectations for the earliest subsistence record, circa A.D. 1240s: Subsistence remains should include domesticates (corn, beans, squash) and wild plant resources used for their seeds, leaves, roots, and tissues. SCP cuisine would have had long-standing traditions that were not focused solely on domesticates (see Minnis 1989). A variety of wood for construction, fires and making of tools etc. should be evident. The ethnobotanical record provides clues as to possible preferences. Historically, much of maize was ground for bread making, the presence of mealing bins and grinding stones present since Chacoan times suggest that archaeological maize was ground and as a result may leave little signature. Depending on the time of deposition, lack of maize may signal pre-harvest, hard times, or the residents taking care to ensure that no corn is wasted. Ethnographic and archaeological records confirm that rabbit and turkey were common food and sources of fur and feathers for blankets, clothing, and ceremonial objects. The hunting of rabbits is recorded historically in ceremony (Whiting 1939:23, see also the "famous" Hopi rabbit sticks usually made of oak). Feather and rabbit fur robes are common in formal burials across the Four Corners (Adams et al. 2011). Larger game animals such as deer may be reserved for more organized hunts and special occasions (Driver 2002; Kuckelman 2007b; Muir 1999, 2007). These events would occur when time taken away from agriculture would not adversely affect yields or were the efforts of dedicated hunting groups. The presence of edible parts in trash accumulations may signal a lack of concern over food waste. The use of specific kiva fuel woods is recorded in historic ethnobotanies. Historic corn wafer (*piki*) bread required the ash of certain fuel wood types to colour the bread. Historically rooms, not kivas, were the sites of bread making, cooking and preparation for ceremonial or clan activities (Cushing 1920).

Notes:

[a] See Kuckelman (2007a:para.18) for an explanation of tree-ring analysis.

The construction of new structures over older buildings (as in block 100) and remodeling of others (the tower in block 200 from its original circular tower construction remodeled into a circular kiva) indicates that there were two Sand Canyon Pueblos, a settlement that existed on the site earlier that incorporated elements of defense (circular towers), and the late stage village configuration that focused on increased security and control. The wall served to provide protection but it also incorporated enough space for continued expansion within. The variety of architectural block configurations indicate that either different groups with differing ideas about building style came together and forged a new identity or wide-scale borrowing of cogent themes occurred. Artifact assemblages indicate self-sufficiency in tool and pottery making, particularly noticeable in western blocks. The content of tools in blocks 100, 200 and 500 indicates that at least one individual in each was a talented toolmaker.

Flotation samples associated with the A.D. 1240s could be distinguished by a combination of criteria including tree-cutting dates or clear associations with construction sequencing:

- Excavated at or near sterile where sterile is clearly stratigraphically differentiated from later deposits.
- Overlain by considerable debris (not just wall or roof fall unless associated with earliest "abandonment" where dismantling of structures for use elsewhere would be evident).
- Recovered from features or accumulations sealed with one or more surfaces and/or strata.
- If associated with a formalized human interment (presence of grave goods, positioning [Kuckelman and Martin 2007]) in strata clearly differentiated as "earliest." No evidence of formal interment is noted for the early record of Sand Canyon Pueblo.

<u>Circa A.D. 1250s: early ideological phase: building "identity"</u>

The construction of the site-enclosing wall is most associated with the A.D. 1250s. The wall was either initiated in this decade or continued through the 1250s in sections (Kuckelman 2007b:para. 3). The wall clearly indicates deepening concerns over defensibility. In order to be truly effective in this regard, the new D-shaped towers, like agricultural fields, would require social consensus, scheduling and special activities. Indeed, towers may well be the most focused spaces at SCP for this reason, provide segregated spaces to define and manage labour and enforce order. Towers 101, 1008 provide compelling evidence for such arrangements.

Block 100 is important for understanding the design and cultural context of SCP. Anchoring a construction time frame for the kiva suite with its early tower and four A.D. 1270 cutting dates from one of two aboveground kivas in the block (kiva 102). These later dates have been used to estimate initial construction for major sections of the block (CCAC 2004, Kivas, Structure 102; Kuckelman et al. 2007). I lean towards the A.D. 1270 dates as reflecting repair. Several lines of evidence support this. The presence of termite evidence in flotation samples provides data that termite infestation was a problem in block 100 (and elsewhere at SCP). Damage to older beams and repairs are to be expected, particularly if the original beams were repurposed from earlier structures (dates in A.D. 1200-1230 are examples, Table 6.1). The site-enclosing wall and the tower were planned in association with an earlier undated structure situated below a rectangular kiva 107. Construction of the site-enclosing wall, or at least sections of it, is estimated in the A.D. 1250s (Kuckelman et al. 2007) and the tower within the same general time frame. The purpose of the configuration of the wall in this location (the curve of the D-shape) would thus enclose empty space if the buildings were constructed later. Support for late dates include little remodeling after the tower and kiva 107 were built. The only exception is the re-plastering of the floor of kiva 108 (the older ancestral style twin of Pueblo III style kiva 102 that sits on its southwest flank). This event extinguished symbolic imagery on the previous floor (dates unknown). However, the activities in block 100 do not display the dramatic cultural reconfiguration we see later in other blocks, such as the great kiva, blocks 1200 and 1500 where trash accumulated in unlikely places. Without such evidence in block 100, a later occupation is possible although also points to a static residency similar to that of the kiva suite in block 500 described later in this chapter. The location of block 100 at the curve of the "bow" of the site-enclosing wall provides support for earlier dates if the original intent was to create or remodel a village to include a deliberate plan for a D-shaped symbolism as seemingly manifested in the D-shaped protective encircling wall. I describe block 100 as a "gateway" to the village, its location strategic, enclosing at least in part, the main water source.

The decade is also notable for the estimated initial construction of block 500 and the great kiva or at least some of its peripheral rooms. The decade wraps up with the initiation of construction of the D-shaped building. If initial building at SCP began in the A.D. 1240s with the intent to create a large protective village, the 1250s consolidates that vision, representing a phase of permanency and organization with the appearance of the great kiva (structure 800).[34] This project confirms that the community was organized in support of a political structure that appears to showcase cosmology, one that persisted from late Basketmaker III times. Keeping to a general (and approximate) 10-year phase

[34] No tree-ring cutting dates are associated with the great kiva at SCP. Dating is based on wall abutments and tree-ring dates with an adjacent and later kiva (structure 808) and a remodeling event in A.D. 1257. The great kiva was built prior to these events. The peripheral rooms that surround the great kiva are dated to approximately A.D. 1267-1273, added later to finished outside walls. If the great kiva was built sometime before A.D. 1267 (Ortman and Bradley 2002) and not prior to A.D. 1257, the emphasis for ideological expansion at Sand Canyon Pueblo appears later. I'm relying on the earlier date, the wall abutment sequence and an assumption that community architecture was planned, developed and managed after some time had passed between initial construction of the village and the full florescence of a leadership structure.

structure, the building of such large communal projects requires planning, a work force and a social structure to support it. Scheduling for the collection and preparation of construction materials, the maintenance of general day-to-day activities and the organization of seasonally specific communal responsibilities, such as the planting, tending and harvesting of domesticates, hunting forays and the gathering of wild plants for a range of uses, would be requirements. In the absence of a dedicated work force, these activities would take time away from such projects. In this respect, the A.D. 1250s seems to be one of shared goals.

The great kiva at SCP provides definitive evidence that social organization was required underpinned by ideology. This reality suggests ceremonial use of food resources. Distinguishing ceremonial use of plants is difficult for the ancient American Southwest because categories of “food” are challenging to interpret as separate or different. Food, whether used for ceremony or day-to-day cuisine, is often regarded historically and in contemporary practice as a singular cultural category. Corn is food but it is also sacred and sacred in any context, public or private. The use of plants was, and is, largely democratic and community-oriented for Pueblo people today (Sekaquaptewa and Washburn 2009). Food as medicine shares similar value. The traditional grinding of maize in ceremonial contexts in historical and contemporary settings serves to make corn much less visible archaeologically. This applies everywhere at SCP including the great kiva. The presence of a mealing room confirms that ground corn was a requirement of the function of the building, at least initially. It appears that room 814 was the original mealing room for the great kiva. It was dismantled early, prior to A.D. 1257 and the metates moved elsewhere. Some of the room’s construction material was repurposed in the building of kiva 808 located directly southwest of the great kiva (A.D. 1257) indicating an evolution in the structures that supported great kiva activity.

Based on kiva 808’s construction date, the great kiva and its original mealing room would have been built prior to this date. Metates found in peripheral room 806 could have served this function later in time. Only partially excavated in a test trench, it is difficult to make a compelling case for the specific use of this “new” room. It is important to note that the great kiva had finished outside wall faces and peripheral rooms were added after this decorative application, evidence that these rooms were not part of the original plan. The presence of large pilasters suggests that at one time a roof was planned or present (Kuckelamn 2007b: para.97). The repurposing of wood beams may explain the absence of evidence of a roof. It is possible that the great kiva was still in the process of evolving in architecture and purpose, another explanation for some of the disorder. As great kiva construction continued throughout the A.D. 1260s, the next phase is distinguished by apparent heightened ideology. The social context of the A.D. 1250s is outlined in Table 6.3 (over).

Table 6.3 Social context of the A.D. 1250s: the construction of community spaces.

Early ideological phase: the development of a communal "identity"
estimated decade: circa A.D. 1250s
previous designation of "early"

Building sequences based on tree-ring dates (CCAC 2004; Kuckelman 2007b; Kuckelman et al. 2007)[a]

- Great kiva and its peripheral rooms 805, 810 and 814 pre-date A.D. 1257 based on the dismantlement of great kiva peripheral room 814 for materials used in the construction of kiva 808, dated to A.D. 1257 (Kuckelman 2007b: para.102).
- Tower 101 constructed after A.D. 1250.
- The site-enclosing wall is constructed or continues to be built in sections (Kuckelman 2007b: para.3).
- Circa A.D. 1252 construction begins in Block 500 (subterranean kiva 501, circa A.D. 1252).
- Circa A.D. 1252 room 506, which opens onto the courtyard surrounding the subterranean kiva (structure 501) may have been built.
- Tree-ring data suggest that kiva 601 may have been built sometime after A.D. 1255.

Expectations for the plant record circa A.D. 1250s:

Subsistence requirements are being met with a variety of food sources for a work force on multiple scales (household and community). Subsistence strategies are sufficient to sustain a village population, major building projects and presumably an ideological cycle in spite of concerns over safety as evidenced by defensive architecture.

Animal food sources should reflect stable patterning with exceptions for important occasions or in public spaces where larger species may dominate (Muir 2007).

Structure 814, a mealing room tied to great kiva peripheral room construction may serve great kiva ceremonial or ritual activities, or planned for such. Celebrations performed on the Hopi Mesas today honour the role of women through male performance, the symbolism of grinding corn clearly identified with gender roles. The sounds of rattles and use of multiple metate bins and two-hand manos are an integral part of the performance. These sacred displays require organization, cultural and gender roles, costuming and identity markers.

Kiva 808 has tree-ring cutting dates to suggest its construction occurred in A.D. 1257. Mealing room 814 was partially dismantled for its construction. Presumably the metates were moved either to this kiva or a peripheral room.

The ethnographic record provides clues for expectations of room use and kiva-specific ceremonial plants. *Atriplex canescens* (four-wing saltbush), *Chrysothamnus* spp. (rabbitbrush), *Rhus trilobata* Nutt. (lemonadeberry/skunkbush/sumac) and *Sarcobatus vermiculatus* (greasewood) are historically recorded for kiva fires (Fewkes 1896; Hough 1897; Whiting 1939:38). Cushing's (1920:385-386) that in the historic period were for ceremonial and ritual purposes. (Whiting [1939] notes the presence of a male "priest" who plays the flute to keep time for women grinding corn in historic mealing rooms, the activity sacred in historical context.) The historic smoking of native tobacco (*Nicotiana*-type) may also be evident (the seeds being recovered in the smallest light fraction particle-sized screens) in such spaces.

Notes:
[a] see Kuckelman (2007a: para.18) for an explanation of tree-ring analysis.

Samples associated with this phase could include a combination of the following criteria:

- Excavated at or near sterile dated to this period, tie-in construction, or in layers overlaying earlier deposits.

- Collected from public architecture may demonstrate a "food" ideology. Food, as Kuhnlein and Receveur (1996:421) note, can be used to demonstrate power or express rebellion. Public architecture would provide the stage for such demonstrations. I suggest that Sand Canyon Pueblo food would be celebratory in this phase. The faunal record of middens may provide more durable and presumably "special" evidence of ceremonial activities.

- Plant foods leave little traces in such communal spaces, which would be kept free of unwanted debris. Associated middens offer the best sampling context to explore the nature of food use in communal vs. domestic spaces.

<u>Circa A.D. 1260s: an ideologically expansive phase</u>

With its strong architectural symbolism, the D-shaped building conveys a sense that a sociopolitical structure and an ideological scheme prompted its development. Best estimates anchor the building of this structure in A.D. 1260 and 1261. Thus it is associated in time with the planning or addition of the great kiva peripheral rooms and the construction of the original courtyard surface in block 1000 over pre-existing features and the kiva (kiva 1206) in block 1200. At SCP, the ethnobotanical record of D-shaped building activities, such as preparations for ceremony, are not easily distinguishable.[35]

The west kiva (structure 1502) was not completed (or begun) until approximately A.D. 1270, which in itself is curious. Like blocks 100 and 1000, the D-shape does not reflect the metaphor or full functionality of its design until the A.D. 1270s, if the dates for the west kiva accurately reflect its construction. The designated mealing rooms from the previous phase(s) indicate the need for bulk grinding, the moving metates and disbanded mealing functions hint at population decline and the diminished need for bulk meal and a diminished importance for structural symbolism. Samples identified with the ideologically expansive phase ca. A.D. 1260s could include a combination of the following criteria. A.D. 1260s samples could only come from midden or trash accumulations and below surfaces due to the change in building use. Identifying features of this decade are detailed in Table 6.4. Samples anchored to this period are found in contexts stratigraphically related to building sequences and could be distinguished by the following characteristics.

- Ritual/ceremonial/religious activity potentially increased in this phase. A signature of contextual plant use or increased discard of refuse could be apparent. The interpretation of ceremonial plant use for food and fuel is unlikely to be visible without good comparative data firmly associated with less "exalted" spaces.
- Ceremony would serve the purpose of displaying and celebrating community, power and/or mitigating for good growing conditions—the "good life."[36] It is

[35] The building changed later to something more mundane with the extinguishing of such features as a large floor vault in kiva 1501 and the addition of mealing bins to both kivas. The remodeling of the very tall west entry doorway into a constricted space and the plugging of doorways between the individual bi-wall rooms clearly demonstrate a reconfiguration of architecture and a shift in ideological imperatives.

[36] Sekaquaptewa and Washburn (2009:204) describe the contemporary Hopi Katsina ceremony as reflections of Pueblo action to achieve cohesiveness and a community-wide expression of 'the good life:' "people are invited to houses and partake in many small meals that are designed to be symbolic of the sharing that ties together all members of the community. They are not 'potlucks' (Kane 1988) that affirm the power of the hosting group by lavish food displays. They are not planned to occur at times of the year when household food stores are low

expected that communal or special buildings would be kept free of unwanted debris. Refuse in sacred places is assumed to be out of place (*sensu* Douglas 1966). The historic and contemporary record realigns the notion of a specific "ceremonial" food as a strategy to reinforce and celebrate cohesive communities (Sekaquaptewa and Washburn 2009).

- New plant types in the archaeobotanical record could indicate immigrants settling in, bringing with them elements of cuisine, medicines, dyes, etc.

The A.D. 1260s is notable for its "late" building date estimates. Kuckelman et al. (2007) suggest that it is the end of this decade that saw a change in the use of block 1200 with renovation effort, an addition of a mealing room and storage filling the space between block 1200's kiva suite and its circular cliff-side tower. This phase captures what is a major cultural shift with the growth of block 1200, the construction of the D-shaped building and the great kiva (Table 6.4).

Table 6.4 Social context of the A.D. 1260s: characterized by construction of ideologically significant buildings.

Ideological expansion **estimated decade: circa A.D. 1260s** previous designation may have straddled an "early, early-middle occupation" category
Building sequences based on tree-ring dates (Kuckelman 2007b; Kuckelman et al. 2007)[a] • Circa A.D. 1261, construction of the D-shaped building begins. This likely includes most bi-wall rooms, kiva 1501, its corner rooms, and a two-storey structure (rooms 1527/1519). • Great kiva peripheral rooms are added "piecemeal" during the A.D.1260s and early 1270s (Kuckelman 2007b: para.110). Still no roof? • Trash from beneath the courtyard 1000 is estimated ca. A.D. 1266. This is the earliest surface for that courtyard. Building in this block seemingly begins around 1266. • Block 1200 construction occurs circa A.D. 1260 to 1266; kiva 1206 built about A.D. 1262. • Kiva 400 probably constructed about A.D. 1265 based on a latest tree-ring date, although the kiva is not fully excavated.
Expectations for the A.D. 1260s and the plant record: Little evidence suggests a cultural "hiatus" period where construction is discontinued and an obvious normality sets in, as the "middle" occupation characterization might suggest. Remodeling and construction continues. The D-shaped building was clearly planned, whereas the great kiva peripheral rooms were added later. Reconfiguration of existing buildings hint at the arrival of new residents or changing alliances. Resources must be adequate to sustain a population estimated to be between 400 to 600 people. Although population density can be questioned for every period, the A.D. 1260s expansion required a labour force and social structure. As is consistent throughout Pueblo history, domesticated turkey, rabbit and hare would dominate the day-to-day faunal record. The need for mealing rooms signals more demand for ground maize.

continued…

(Potter and Ortman 2004). They are not used as opportunities for the host to control the labor of others in the hunting and preparation of food (Potter 2000)." They go on to affirm, "[t]hese meals are not prepared as displays of status or power nor are they bids for control. Rather they are seen as symbolic of the renewal of the communal spirit that sustains the community." The ceremonial kiva then should reflect nothing different in terms of plant remains than the everyday domicile with the possible exception of kiva fuels and tobacco remains.

Table 6.4 Social context of the A.D. 1260s, characterized by construction of ideologically significant buildings continued.

Expectations for the A.D. 1260s and the plant record continued:
Pre-existing traumatic injuries are seen on skeletal remains confirming violent encounters or accidents to some residents were acquired prior to or during the occupation. These injuries suggest that life at Sand Canyon Pueblo was not without its trauma. Injured people may reflect a working or labour class—“others” who may not receive normal considerations in life or in death (Kuckelman and Martin 2007). Normal mortuary practices should reflect formal interment, deliberate positioning and may include grave goods. As expected in the previous period, grave good may include plant remains. A burial in block hint at mortuary practice or evolving mortuary treatment.

Notes:
Sse Kuckelman (2007a: para. 18) for an explanation of tree-ring analysis.

Circa A.D. 1270s: the D-shaped building completed, major transitions, onset of severe drought

The early-mid 1270s is ushered in by the estimated construction of the last block (the major buildings in block 100, if the late dates accurately reflect initial construction, which I suggest they may not). With this building sequence, we can assume that the environmental and cultural conditions around Sand Canyon were attractive enough to continue to draw new residents. Sufficient resources and energy to embark on remodeling or expansion would be necessary to justify continued acceptance of new people. If resources were stretched too thin for the existing inhabitants, it is unlikely that new people would have been welcomed. This is another reason to re-explore the construction estimates for block 100. A.D. 1274 is very late for new arrivals, occurring as drought conditions loom or are beginning to impose problems for agricultural productivity.

A critical year in this decade is A.D. 1276, the tree-ring record indicates clear declines in water availability. Although the onset of drought was likely a major turning point marked by what would become prolonged and severe conditions (Kuckelman 2007b:para.55; Douglass 1929), it is not necessarily *the* defining year in social context. Previous evidence of transitions and fractiousness can be seen in the blocking of doorways and discarding of trash. Unstable weather patterns, if they existed prior to A.D. 1276, likely warned of the conditions to come for a people who would have been well tuned to ecological clues. The changes in behaviour perhaps linked to more ominous social issues.

The west kiva within the D-shaped building is dated to A.D. 1270 (CCAC 2004; Kuckelman et al. 2007), approximately ten years after its eastern twin. The multiple re-plastering of the floors and walls within the kivas suggest that D-shaped building activities continued for some time. If re-plastering was done annually as is known for contemporary pueblos, at least four years passed before the building use changed. This could situate change after A.D. 1274 and the reconfigured use of block 1200 at the same time as the proposed construction of the later kivas in block 100. It is unlikely that trash would accumulate in haphazard ways if a new social order from outside appeared and overwhelmed existing residents, particularly in such a constrained time period. The SCP people's deep history included both the Chacoan construction of "D"-shaped buildings and great kivas in centuries past, and the massive stripping of trees to achieve those ends. These activities had very clear outcomes. Diminished or absence of easily acquired basics: fuel wood for heat, light and cooking. This could not have been the case for Sand Canyon if construction continued into the late 1270s, even if structural beams were repurposed. A last cutting date of A.D. 1277 certainly indicates that beam-sized trees were still available in the area and construction continued.

Migrations out of the region, too, are not unexpected as families fission and reconfigure. However, movement to other landscapes would be a last resort for creative and adaptive people who were well entrenched architecturally and had time-tested subsistence strategies in place. Clearly the residents of Sand Canyon were not, *en masse*, considering complete abandonment of the Mesa Verde area until at least some time after the final construction beam was cut (A.D. 1277) and the final attack. If drought was causing widespread food shortages, the fear of violence so evident in the scale and configurations of the architecture may have transformed in later years to focus on internal factions competing for space, food or power. Alternatively, pueblos rich in stored food and known for agricultural productivity would be attractive to outsiders hoping to capitalize on their labour. In any case, the production of maize likely played a significant role, the underlying metaphor of maize signals power and the control of food production.

Not a "simple" subsistence, the control of maize production and distribution creates a menacing situation inextricably linked to food insecurity particularly when there are competing groups and conflicts in leadership. Drought conditions add an additional stress as Chaco Canyon testifies. In such cases as these, elaborate food procurement takes a back seat to efforts to remove or respond to imminent threat, as we know all too well of war zones today. The D-shaped building may have been built to mitigate, in an ideological and ritual way. Its completion seemingly dragged out until about A.D. 1270 with the final twinning of kiva 1501 suggesting both more pressing concerns caused delays or, as I argue in the final chapters, represents a deliberate vision of power and capability. The destruction of an inner wall face in the great kiva complex (peripheral room 805) that plausibly was destroyed due to its symbolic imagery, provides additional evidence of a possible backlash against an ideology or a leadership structure that failed or was unwanted in the area. A possible influx of new residents, abandonment by previous inhabitants, or other phenomena imposes a new, disordered "order." Threat takes on a new face in later years, the period ending in a warfare event. The apparent suspension of a warrior-focus possibly symbolized in the metaphor of the "D" occurs in this final stage. The shift in use of the D-shaped building suggests that either the original users of the building left, perished elsewhere, or returned later with a vengeance. The attack, in the last days or weeks of occupation, takes its toll on an apparently unprepared or insufficiently protected populace. The provenience, preservation potential, types of plants and plant parts used, and the imposed processing, contribute to unidentifiable remains or an “invisibility” of plant remains in these latest deposits.

In their analysis of the Sand Canyon Locality archaeobotanical record, Adams and Bowyer (2002) did not find evidence to support a major change in resource use. Only in latest deposits, those of final fires that occurred in abandonment or postabandonment contexts, did they note an increase in the ubiquity of *Opuntia* (prickly pear cactus) and weedy species such as cheno-am (*Chenopodium/Amaranthus* or goosefoot/pigweed types), *Physalis* (groundcherry), and *Portulaca* (purslane) pointing out that this could represent a wider reliance on wild plants (Adams et al. 2007; Kuckelman 2007b). The apparent ubiquitous decrease in use of pine species as fuel material in latest fires, and increase in the use of shrubby plant fuels they argue, is suggestive of environmental disturbance or degradation, causing a demand for reliance on non-typical fuel sources. No evidence of starvation or a starvation response could be gleaned from the data, however (Adams 2002:140-141). In this respect, a re-analysis of these species through additional sampling helps to illuminate the record further. Samples associated with this transitional time frame could include the following criteria:

- Those stratigraphically positioned to reflect co-occurrence with dated building, dismantling and reconfiguring events.

- The blocking off of certain access points hints at heightened social unrest. If towers and adjacent rooms were considered to be ritually controlled spaces, samples associated with earlier surfaces would hold clues to such activities. Towers (structure 1008, tower 101), the D-shaped building (block 1500) and block 1200 midden (nonstructure 1214) could provide supportive evidence. Like block 1500, block 100 holds compelling evidence of an original cosmology.

- Poor maize yields would lead to problems in maintaining domesticated turkey populations. The SCP faunal record shows abundant turkey, rabbits and small mammals, typical Pueblo III diet. Whether the plant record is robust enough to support interpretations of shifts in cuisine is debatable.

- Building continues until A.D. 1277 (A.D. 1271 for kiva 1501). Subsistence needs must be adequate to allow for both a construction and a subsistence labour force. Samples should continue to yield a variety of food refuse, although perhaps dietary structure becomes less broad with more focus on easily available resources.

- Midden 1214 provides clues as to the effectiveness and variety of food availability in the later years. The abundance and variety of this deposit may or may not be attributable to expanding food needs. In the case of shrubby fuel wood types, the ethnographic record suggests that shrubs were the typical fuel

> sources, not tree wood, for historic Hopi fires for cooking, heating and light. We should continue to see shrubs in fires at SCP based on tradition versus a strategy to buffer fuel wood shortfalls.

The transitional period, as I have outlined here, straddles two very different cultural responses: the apparent "abandonment" of certain buildings and the continued building of public architecture (great kiva peripheral rooms, kiva 1501). The construction of a new block (block 100, if late dates are considered first construction and not repair dates), the onset of drought (circa A.D. 1276) and what appears to be a drastic shift in ideological imperatives indicate that life at Sand Canyon Pueblo may have initially settled in well and continued to evolve. The power of public spaces shifting into a new configuration, albeit brief, suggestive of an agitated or depleted population whose concern for "normal" cultural expression and expectations, such as the culturally acceptable deposal of trash, is of secondary concern. The beginning and length of the transitional phase is the most difficult to understand, appearing to coincide initially with the late A.D. 1260s, early A.D. 1270s with the repurposing of rooms (midden 1214 is an example). The content of the midden does not reflect "hunger" or subsistence stress but rather, abundance, diet breadth and what could simply be a lack of concern over food waste and residents who no longer required a dedicated mealing room in this particular location. If this abundance is the result of expanding food collection to mitigate plant food shortages, then we need to consider the danger inherent in leaving the general vicinity of the protective walls of the village for a people that clearly had concerns enough to ensure their water source (see LeBlanc 1999). The mealing room transition to midden could be a response to the need for burial areas. Built on rock, most areas of SCP lack matrix for proper burial. Traditional graves within villages can be seen in ancestral sites, Pueblo Bonito's burial rooms are a classic example. Discarded plant materials could serve the purpose of creating a matrix. The burial of a young woman (inferred) in midden 1214 suggests this was the case. The A.D. 1270s provides evidence that the residents were living under unusual or unexpected conditions. The onset of drought would be anticipated to cause problems for people who had little or no stored foods. The growing of maize in arid conditions, however, demands adaptive technological responses.

Ancient check dams for capturing rainwater run-off, planning and planting for excess are hallmarks of Ancestral Pueblo. Throughout the southwest, from Basketmaker times, storage was an essential component of the food system; the pits, bins, containers and rooms of the ancient Puebloans used for the storage of seed corn and winter supplies that included domesticated and wild resources, Sand Canyon Pueblo is no different with its large bins and storage rooms. ..Major events and expectations for this transitional period are outlined in Table 6.5 (over).

Table 6.5 Social context of the A.D. 1270s: characterized by transitions in the use of architecture and onset of severe and prolonged drought.

Transitions: public spaces becoming private, drought estimated decade: circa A.D. 1270s previous designation categorized as "late"
Building sequences based on tree-ring dates (Kuckelman 2007b; Kuckelman et al. 2007)[a] • Building continues; kiva 815 near the great kiva dated to A.D. 1269. • Great kiva peripheral rooms added (Kuckelman 2007b:para.110). • Circa A.D. 1270 the "twin" kiva, 1502, is added to the D-shaped building. • Kiva 1501 had a functional subfloor vent system at abandonment; the hearth may have been in use until the final attack. • "Last" block (block 100) could have been constructed around A.D. 1271 (with the exception of tower 101, which was built sometime after 1250 (CCAC 2004). Four construction beams from the early A.D. 1270s possibly indicate repair, not an initial building episode. • Changes in the use of public architecture moves from communal/ceremonial to increasingly domestic as this phase abruptly closes.
Expectations for the A.D. 1270s and plant record: Firepits or burned spots hint that cooking/heating and light are increasingly needed in uncommon spaces. Conversely, such feature types may also reflect typical activities, not necessarily about "cooking" but for the processing of plants for dyes and medicines. Historically, firepits were common in rooms for the cooking of food, for day-to-day living. Clan-related activity and ceremony was historically relegated to separate rooms. Hearths are cleaned after use unless the activity is interrupted. *In situ* remains reflect the final use of the feature. Fuel wood could reflect the re-use of old wood from scavenged buildings. This may be in response to depleted natural resources, fear of collecting trips outside the village, convenience or tradition. The ethnographic record supports indigenous use of many shrubs in fires and hearths as typical, i.e., not related to lack of tree wood. Even burning old construction beams would have its limits. Several reasons might exist that would cause people to use public architecture for domestic purposes. For less exalted people (if there were such divisions) to take over ceremonial structures suggests that ideology was under assault. Such change could indicate that the population increased and living requirements demanded a re-use strategy. It may also reflect the emigration away from the village by people or groups that controlled activities within these spaces. The presence and content of trash in ritual spaces may hint at changing perceptions and priorities. A signature for collapse of dietary structure due to resource stress or agricultural shortfalls should include a decrease in the use of both domesticated and wild resources each being adversely affected in unstable environments. Trash accumulations should therefore show a decrease in plant remains generally, reflecting a concern over inadvertent food discard. Faunal evidence suggests the hunting of small mammals and birds, a typical Pueblo III strategy, continues.

Notes:
[a] See Kuckelman (2007a: para.18) for an explanation of tree-ring analysis.

We associate difference between domesticated and wild foods although these conceptions of "wild" and "domesticated" are research categories but one that may not reflect food system that did not recognize similar difference. Ridington (1982:473) provides a deeper explanation:

> The Beaver people [northern Athapascans] viewed human experience as a life-sustaining network of relationships between all components of a sentient world. They experienced their world as a mosaic of passages and interactions between animate

> beings in motion against the backdrop of a terrain that was itself continually in process, through the cyclical transformation of changing seasons.

Plant foods are managed traditionally in the archaeological and historic period as part of a complex system of knowledge and practice, the strategies for which marked, and are marked, on the landscape of North America (Berkes 2008 [1999]; Dods 1998, 2002; Turner 2005). "Domesticate" and "wild" are seasonal categories where the cultural cycle of planting and procurement is "food," dictated to by the seasons and the positioning of the sun.

Continued construction at SCP using large newly cut beams confirms that there were enough resources available to allow for building expansion and, therefore, sufficient food for labour. If construction stopped in A.D. 1277, with the latest cutting date, then building continued after a year or more of harsh drought conditions. Perhaps, though, by the onset of drought, they would have been living on borrowed time. Regardless of the reasons, the next proposed phase, "catastrophe," reflects just that. This "decade" begins and ends circa A.D. 1277.

<u>Attack—circa A.D. 1277: catastrophe and post-catastrophic residency</u>

Approximately A.D. 1277, a vicious attack led to violent death and the callous treatment of human remains (Kuckelman and Martin 2007). The human toll would have been catastrophic for associated family, felt throughout much of the Mesa Verde area. Many villages suffered the same fate. People were not formally buried. Others were "badly treated," the scattered and fragmented bones of "deliberately mangled" people littered the sites (LeBlanc 1999:162-163), the result of unnatural deaths that occurred throughout Ancestral Pueblo time, apparently including Chaco and, before that, during Basketmaker times. At SCP we see a brief stay or revisiting confirmed by the ephemeral thermal features on collapsed buildings. These small expedient fires suggest that people returned to "close" the village through the burning of kivas. Continued presence of aggressors in the area may also be a cause. If so, neither group would have been squeamish about setting up camp in the presence of the remains of brutalized people; that is, unless the return occurred after sediments obscured the evidence.

Samples associated with the final events are clearly found directly beneath or in close association with human remains. Inferences in these locations suggest activities just prior to trauma. In the case of burned spots in roof fall or on collapsed buildings, the content could be the result of later campfires. As for teasing out subsistence to speculate on causes and effects, the timing of the attack is critical. Whether the event occurred pre-harvest, post-harvest; the time within a twenty-four hour period such as pre-meal, or post-meal has implications for the interpretation of the plant record in the catastrophic context. To be ultimately effective, the attack would have been planned to ensure success, either in the early hours of the morning and/or during a working period in the fields. Alternatively, it could have been planned when warriors were elsewhere. Characteristics of this phase are outlined in Table 6.6.

Table 6.6 Social context of circa A.D. 1277: characterized by brutality and depopulation.

Catastrophe and post-catastrophic residency **estimated date range: circa A.D. 1277 – A.D. 1280s** previous designation "late" [around the time of depopulation] and "latest" [ephemeral re-use] (Adams et al. 2007: para. 57)
Building sequences based on tree-ring dates (Kuckelman 2007b; Kuckelman et al. 2007)[a] • The latest tree-ring date known for SCP is A.D. 1277 (Kuckelman 2007b: para 8). • Sometime after A.D. 1277, the village was attacked (para.51). • The subfloor vent system in kiva 1501, the latest kiva in the D-shaped building, constructed (or remodeled) some 10 years after its "twin," kiva 1501, is still functional; others are not. • Kiva roofs are burned. • Ephemeral fires in roof and wall fall and other unexpected locales suggest post-abandonment occupancy, duration likely short. This revisiting of SCP could have occurred at any time after abandonment.
Expectations for the plant record: The overall health of the residents was good for its time (Kuckelman and Martin 2007). To be visible, skeletal changes would require long-term scarcity. The seasonal timing of the attack should impact the types of accidental food discard in thermal features: pre-harvest may explain a lack of maize remains, the use of ground maize products would leave little signature. Long-term drought is expected to leave its mark on both floral and faunal record. Small mammals can make up for shortfalls in larger protein sources, such as deer or other larger animals. The use of rabbits, gophers, squirrels and mice, however, are typical protein sources in the Pueblo III period and should be assessed as typical diet (Sutton and Reinhard 1995). These remains persist throughout the occupation.

Notes:
[a] See Kuckelman (2007a: para.18) for an explanation of tree-ring analysis

The remains of those who perished hint at timing and purpose also. Targeting the most vulnerable was perhaps the intention. The interpretation of "last days'" plant use is a combination of evaluating earlier times and speculating on timing. Many factors could explain presence or absence of plant evidence (sampling may be one). The final events, attack and post-attack occupancy, are problematic in that ephemeral features such as firepits and burned spots may contain evidence of activities associated with a raiding or a travelling group of unassociated people, the remains reflecting their own provisions. Unsettlingly as it is, however, last days plant accumulations are the most clearly identified by warfare evidence.

Each temporal stage I have proposed here helps to ground the assessment of sample adequacy and explore impacts on the interpretative value of flotation samples. The decade/phase scheme is a convenience based on behavioural evidence. My timing estimates helps to tie the material remains to rational human behavioural responses, the reality that people who live in place for generations are knowledgeable, deeply embedded and practical. It is ultimately the wider contexts of the architecture, art, tools, plants, animal remains and other evidence that inform the assessment of archaeobotanical sample content and the "adequacy" of any sampling strategy. In the next section I expand on the archaeological context of samples evaluated for this study in an effort to provide a well-supported comparative analysis.

The archaeobotanical keystone: block 100

For the remainder of this chapter I review the archaeological evidence and focus on particular excavation units for their interpretative potential and reflects only a fraction of the information available. Three considerations are scrutinized for their potential to shed light on the archaeobotanical record: tree-ring cutting dates, human remains, and plausible behaviours. Tree-ring cutting dates allow for speculation as to the general timing of sample deposition, the human remains inadvertently encountered during excavation provide skeletal evidence of disease and health conditions to illuminate plant choices. The architecture, art, and artifacts reflect how people lived their lives and responded to changing conditions, both cultural and ecological. [37] In the discussion that follows, I provide descriptive labels for excavational areas so aid in the discussion. This anchors my interpretations in material culture, the recovered evidence of how people lived at Sand Canyon Pueblo. Block 100 is the cornerstone of my interpretation of the site. Here concrete links can be made with historic and contemporary Pueblo religion that is further elaborated in block 1500. Ethnographic data shed light on the social organization of the village that I claim is clan-based. URL links to CCAC's architectural drawings allow for a more complete understanding of the discussion and readers are advised to access these sources.

The "bear" block[38]

Located on the northernmost boundary and western arm of the pueblo, the intensive excavation of block 100 included three kivas, a D-shaped tower, seven rooms, and portions of two middens (Kuckelman et al. 2007). A use surface outside the site-enclosing wall is located near the tower in this block (arbitrarily selected and defined as Arbitrary Unit 1 [CCAC 2004]). An abundance of tree-ring cutting dates in the A.D. 1250s (kiva 102) are a plausible decade of construction for the majority of the excavated block (Table 6.1, pp. 138-139). People were living here at the time of the final attack

[37] Many studies of Sand Canyon Pueblo have been published as noted throughout this chapter. The description of depositional contexts and architectural blocks is taken, for the most part, from the SCP database (CCAC 2004).

[38] Block 100 as excavated is shown on Map Number 4005 Site 5MT765 Block 100 Topography made available courtesy of Crow Canyon Archaeological Center (CCAC 2004) at: http://www.crowcanyon.org/ResearchReports/ResearchDatabase/maps/qryMapZoom.asp?FileName=e:%5Ceditor%5Cmaps%5C5MT765%5CMap4005.tif&Zoom=30&Site=5MT765&MapNum=4005&RequestPage=&RequestPage=All_Maps_Page&MapType=WSCulturalUnits.

and human remains were inadvertently encountered in excavation. Study samples came from arbitrary unit 1, a kiva (kiva 102) and a midden (midden 109). The early analysis of block 100 samples by Scott and Aasen (1985) provides the most compelling evidence of plant use, a collection of plants that are unusual for their pharmacological potential.

Block 100 is exceptional for its cultural content and comparative potential. Evidence of older structures (the first hints of Sand Canyon Pueblo?), intriguing architectural design and location, symbolic imagery and human relatedness within the block and between blocks (with block 1000) give this kiva suite an unusual configuration of traits. Here, too, are the remains of unusual and unique species of plants. I characterize the plant record for the block as the "*Cleome*" suite for the scattering of *Cleome* (beeweed, beeplant, spiderflower) seeds recovered from a variety of contexts. Not limited to this one pharmacologically important species, Scott and Aasen (1985) identified other plant remains here that are also notable for their use in ethnomedicines that would provide its residents, some of whom suffered from what could only have been debilitating disease conditions, with a medical toolkit. The plant record holds interpretative power for understanding something of the social organization of the pueblo and last days and weeks of residency.

The structures of block 100 are located on the northernmost curve of the site-enclosing wall within the "bow" of the D. The construction sequence began early with buildings pre-dating the D-shaped tower (structure 101). Separated from unexcavated kivas and room blocks to the south and east by a courtyard space, the block appears to protectively border or share boundaries with block 1000 located on the east curve of the "bow," separated by the drainage and the side canyon that divides the village. Whether this area was a major entry point into the village serving as a gateway, the two west and east blocks (100 and 1000) were apparently connected, at least as boundary markers. Access to what must have been the most culturally important Sand Canyon Pueblo buildings, such as the D-shaped building and the great kiva, requires travel around or through a large room block (the "back" of block 300) through a corridor that passes by block 400 on the canyon side (Figure 6.3, p. 133). Entry to the east kiva was accomplished either through an entryway on the building's east side (unexcavated and inferred), by ladders to a main hatchway or by passing back around the building through the peripheral rooms that surround the west kiva (kiva 1502) and moving through the east side peripheral rooms (kiva 1501)(Ortman and Bradley 2002). Ortman and Bradley (2002) make a compelling argument for an apparent heightened symbolism of the east kiva versus the west kiva and the pathways of movement within the building that mimic the circular representation of Puebloan cosmology and Emergence symbolism.[39] This assessment proves particularly compelling when viewed from the material record of block 100. Access to the great kiva from block 100 is more convoluted. This would require travel through many existing room blocks or by accessing the plaza surrounding the southeast portion of the kiva by way of the contours of the cliff that, on the face of it, would require navigation of drop off. As large and imposing structures, the great kiva and the D-shaped building were likely important destinations for all residents of Sand Canyon Pueblo, the movement of block 100 people is, by virtue of their location in the curve of the bow and in relation to the drainage and permanent spring is suggestive of the Emergence of the Bear clan in myth and the importance of the Bear clan and its privileged position in Pueblo life and religion. Illusions to the entryway into this, the Fourth and contemporary World through a reed ladder (Parsons 1996 [1939]) has some resonance with the spring here. Further material remains solidify block 100 as culturally significant within a cosmological order fully expressed in the historic period.

Block 100 consists of more kivas than rooms.[40] Similar to blocks 200 immediately to the south and block 1000 directly across the drainage, it could have been vulnerable to "outsiders" being situated on the periphery of the site-enclosing wall and the break at the drainage, the canyon itself was likely a sufficient deterrent to attack on the canyon side. Defensive towers built onto, or as part of the site-enclosing wall, are recorded only in these three blocks (Figure 6.3, p. 132). These locations were clearly identified as good siting and defensive locales for covering the west, north and northeast, or were more vulnerable or a combination of both. Tower 101 was clearly planned in conjunction with construction of the site-enclosing wall. The callous deposition of human remains with lethal injuries was encountered in room 105 (a robust middle-aged man), kiva 107 (a frail young woman), and kiva 108 (two young adults or adolescents). The last two victims also had remains scattered in other rooms. The body of an infant was found in a disturbed midden (103) located outside kiva 102. The apparent absence of maize and presence of *Opuntia*, possibly a non-preferred food in the context of the kiva suite has been inferred as evidence of resource stress. An alternative explanation for these remains also indicates a particular, seasonal Ancestral Pueblo diet.

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[39] The Emergence belief centers on the three subdivisions of the underworld. The Pueblo people emerged from each, gaining more knowledge, much as plants emerge from the earth into this current "Fourth World." "The middle or center of the cosmos is represented by the village and by symbolic representations of the place of emergence: the *sipapu*, or the earth navel." (Eggan 1972:297).

[40] Map 4021 Site 5MT765, Excavated Portion of Architectural Block 100, East Wing, Plan View shows the excavated areas of the block. Made available courtesy of Crow Canyon Archaeological Center (CCAC 2004): http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4021.tif&Zoom=25&Site=5MT765&MapNum=4021&SUNum=102&SUTyp=Structure&SUDesc=aboveground+kiva&StartingSUTypePage=Structure_Page&Crit=Kivas&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Structure_Page&RequestPage=MapList_Page

Block 100 plants: interpretative challenges

Distinguishing typical diet and availability of food resources, resource stress responses, and plants used for medicine are challenging for archaeobotanists. Consumption does not necessarily equate to diet, coprolite remains can be the result of inadvertent consumption or deliberate consumption of medicines. These interpretations are less challenging in block 100 because of its unusual combination of plants. The question of maize and *Opuntia* as indicative of poor agricultural yields and non-preferred food sources is one noted for latest occupation flotation samples. On review of Scott and Aasen's (1985) block 100 analysis and the record for Sand Canyon Pueblo, the plant assemblage in reflects what Minnis (1989), Reinhard (2006), and Sutton and Reinhard (1995) demonstrate are typical plants consumed during the Pueblo III period based on coprolite research: ground maize, wild seeds and grasses, cactus, and the almost always ubiquitous, cheno-am. Exploring the apparent lack of maize and the apparent increase in *Opuntia* combination allows for further insights into last days subsistence.

Sutton and Reinhard (1995) present a case for an Ancestral Pueblo milled maize cuisine based on Antelope House coprolite analyses.[41] Their categorization of a Pueblo III "nonmaize cuisine" includes a variety of wild seeds. Evidence of milled maize and wild seeds was certainly present in the tower. In a sample of 68 coprolites, Minnis (1989) categorizes a stable "core" diet from Basketmaker III through Pueblo III in the Four Corners that consisted of domesticates and "weeds," a suite of *Zea mays* (corn/maize), *Cucurbita* (squash), *Chenopodium*, *Portulaca*, *Physalis*, and *Opuntia* prickly-pear. By late Pueblo III this core diet was, on average, 70 per cent herbivorous where 40 per cent of that consisted of maize in milled or whole form (Reinhard 2006). Obviously thirty per cent was "wild." At Sand Canyon Pueblo, *Zea mays*, *Cucurbita*-types (pumpkins and squashes) and *Phaseolus vulgaris* (common bean) were recovered in both vegetative and flotation samples, although

[4141] Antelope House is located in Canyon del Muerto, Canyon de Chelly National Monument, Arizona, and was excavated by Don P. Morris in the 1970 (Morris 1986). A sampling from the preliminary report of late Pueblo III coprolites by Fry and Hall (1975) identified seed remains from *Amaranthus* (pigweed), *Chenopodium* (goosefoot), *Cleome* (beeweed/beeplant), *Cucurbita* (squash), *Equisetum* (horsetail), *Helianthus* (sunflower), *Lepidium* (peppergrass), *Opuntia* (prickly pear cactus), *Oryzopsis* (ricegrass), *Panicum* (a panic or switch grass type), *Physalis* (groundcherry), *Pinus* (pine), *Portulaca* (purslane), *Rhus trilobata* (skunkbush/lemonadeberry), *Sporobolus* (dropseed grass), and *Zea mays* (maize/corn). Cluster analysis by Sutton and Reinhard (1995) found that milled and whole kernel maize were not found in the same coprolites and were "mutually exclusive," which they interpreted to represent two very different consumption conditions demonstrated statistically: stored and ground sources when fresh maize was not available, and kernels and cob evidence when harvest occurred (746). Milled maize was found in association with only six other resources: milled or whole chenopods, amaranths, *Portulaca*, *Sporobolus,* fibre (thought to be *Yucca*) and *Rhus* in milled or whole form. The coprolites that did not contain maize did contain *Pinus edulis* (pinyon pine), *Physalis*, *Chenopodium*, *Equisetum*, *Sporobolus*, *Amaranthus*, *Cleome*, *Opuntia*, *Rhus*, *Gossypium* (cotton), unknown fibre, Poaceae, *Yucca*, *Oryzopsis*, and cheno-ams. Their conclusions: "The fact that ground cheno-ams occur independently of maize indicates that there was a processed food that was derived solely from wild seeds.

Phaseolus is less commonly recovered at least in part due to the tendency of the seeds to easily degrade. *Phaseolus* was found in accumulations associated with kiva 102, kiva 208 (in block 200), and in a few midden and surface deposits in abandonment contexts (that is around the time of the raid) in floor and roof fall samples. Clearly, people retained core foods that included stored or recently harvested beans in the latest episodes of use. It is also clear that the residents of block 100 and elsewhere had access to a wide variety of Pueblo III staples not limited to wild or domesticate in the last days.

Coprolite evidence is clear, domesticates did not replace wild food sources but rather contributed to diet breadth. Reinhard (2000:131) confirms: "hunter-gatherers had a less diverse wild-plant-food base than horticulturalists," where maize farmers encouraged wild weedy species through the disturbance of soil, used wild plants to add nutritional content to their maize diets, relied on stored wild plants to "spice up a relatively bland maize diet" and counted on wild plants to respond to increased demand with population growth. The plant remains recovered from tower 101 and other buildings in the block indicate similar findings but also tell us is something about priorities, not so much about "meals" because it is the combination and variety that is decidedly different here. It is unlikely that these plants represent wild adaptations to domesticated food stress as has been suggested. The typical grinding of maize for flour can explain the fragments of maize noted for the tower, possibly signaling a pre-harvest time frame which fits well with the faunal evidence for what appears to be a fall hunt.

The question that hangs over block 100 is, what was the purpose of the final catastrophic raid on Sand Canyon Pueblo? If food shortages propelled the attack then we can reasonably assume that the goal was to raid for food. The most effective time to do this would be immediately post-harvest of maize. By doing so no intensive harvesting effort would be required of the raiders. The presence of remains of large game animal bones in combination with typical fall season resources such as *Physalis, Opuntia* and *Artemisia tridentata* seeds and achenes situates these SCP last days in the fall, a time of harvest or celebration of harvest and preparation for the coming winter. Maize may not be present because was taken or yet to be harvested. Evidence of ground maize was present around the site (additional samples confirm this) in the final days. Sutton and Reinhard (1995) coprolite case for a seasonally specific milled maize cuisine and pre-harvest maize diet fits well with last days use at Sand Canyon Pueblo. Another issue is the typical inference of *Opuntia* as a "famine food," A critical analysis of the ethnographic record and the food stress argument demonstrates that there are other compelling reasons for the presence of *Opuntia* and absence of maize.

Opuntia*: feast or famine?*

The typical characterization of Opuntia as "famine food" is based on briefly described ethnographic accounts that may well reflect a misunderstanding by early ethnographers as to the importance of cactus as a food, a medicine, and for its cosmological importance. In his 1897 report, Hough makes the following observation of *Opuntia* for the Hopi, "the stem is boiled and eaten in the spring when food is scarce" (38). In this regard, the "stem" is appealing as an early spring food, when fresh food was not readily available. Cushing describes *Opuntia* from the Zuni perspective as the "fruit that rarely failed" (1920:237). Desirable for its predictability and sweet taste, various species of *Opuntia* gathered during its flowering provided "the largest and perhaps sweetest fruit ... the low-lying chain cactus, bore red and yellow fruit which, though smaller, was more luxuriant and less spiny, hence preferred," celebrated in ceremony and in clan associations (237). Whiting (1939:9) lists cactus fruits (unspecified species) as a seasoning that was stored in bundles and kept in the house along with *Allium* (wild onion), *Mentha canadensis* (mint) and various species noted as beebalm (*Monarda* [mint], *Pectis* [pectis], and *Poliomintha* [rosemary mint]). Under the heading "when the crops fail," he lists the "joints" of *Opuntia* sp., *Lycium pallidum* (pale wolfberry but recorded as *tomatilla*) and the dried greens of *Acanthochiton wrightii* (known today as *Amaranthus acanthochiton* Sauer or, greenstripe). These are categorized as a "starvation" food in some sources (Moerman 1998). Cushing (1920:238-242) provides the following description of *Opuntia* that does not support the plant as a non-preferred food source relegated to famine conditions and bad times:

> When a basketful had been gathered it was carried home and emptied upon a bed of clean sand. With two flat sticks the fruit was then stirred about in the sand until divested of its spines, after which it was eaten raw, dried, or roasted slightly in the ashes as an additional security against the spines. Large quantities were gathered for preservation by drying, but as the fruit thus prepared was liable to injury by worms, it was usually ground on a mealing slab and either stored away in skin bags, to be used in connection with other material for bread-making later on, or formed into huge cakes by the addition of water which rendered it adhesive so as to be easily molded in baskets.
>
> Undoubtedly, many generations later these fruits of the cactus played a leading part in the food economy of the Zuñis and apparently commemorative of this is a highly picturesque dance usually celebrated by the modern Zuñis in early spring and called the "Beings of Old." In this dance, are represented an ancient woman with narrow, hollow-cheeked, remarkably long and prominent-chinned mask, gray frizzled hair, a tattered cloak, and short worn skirts, which although made of cloth, evidently represents the prehistoric costume of the tribe. Her feet (with the exception of makeshift moccasins representing sandals) and arms are bare, although painted like the mask, pink. Strapped to her back is a *hu´-tche-pon*, or one of the quadrangular burden-baskets previously described, and in her right hand she carries one of the forked wooden cactus-tweezers, while she grasps with her left hand, as if for support, a long wooden staff like a shepherd's crook. This character is called *Ya-a-na tui´-ash-*

> *na O'-k'iät-si-ki*, or the "Ancient moon-woman cactus-picker." During the performance of the ceremonial, she wanders about, industriously striving to overtake an equally grotesque character that as ceaselessly eludes her pursuit. This latter is a man whose face and head are covered with a cylindrical rawhide mask painted green, the eyes being represented by diminutive, elongated, square holes, while a huge black beak well serrated and toothed represents his nose and mouth. The crown of his mask is entirely covered with leaves and branches of the green cactus, on which are seen, temptingly red among the spines, the *tui'-a-we*, or ripe fruit. As the cactus, on account of its warlike spines, is assigned, by the mythology of the Zuñis, a place in the martial priesthood of plants, this man, clothed in the ceremonial garments of the sacred Zuñi dance (which are of cotton beautifully embroidered), bears in his left hand the insignia of war—a bow and several arrows, and in his right a rattle with which he teases his pursuer. Two other figures among the *dramatis personae* of this dance claim our attention because related to the pair described. They are, one of the corn beings masked and bearing in either hand an ear of corn, and a man, dancing ever near, whose face is covered with a smiling, conical, pink mask, whose hair is bound with a fillet of yucca fiber, whose costume is a many-colored blanket cape and embroidered cotton kilt, and who carries, as emblematic of his office, a little wooden hoe of the ancient style [tchamahia (van Roggen)] [42]...While the "Old" and the "Cactus Being" ceaselessly pursue and elude each other, the "Corn Being" and the "Cultivator of Corn" dance with the other characters in sublime indifference. All this is wonderfully poetic and significant, if, as it seems, it represents the personified conflict between the wild fruits of the nomadic Zuñis and the cultivated harvests of their sedentary descendants; and that this significance is as it seems is indicated surely by the wild, triumphant song-notes of the "Corn Being" and its follower, and the querulous cries of the baffled cactus-picker."

As a "food that rarely fails," the cactus in Ancestral Puebloan mythology is representative of war and the challenge associated with collection because of the spines. Two clan names are recorded as *Opuntia* evidence that prickly pear cactus was something more than a starvation food. The effectiveness of *Opuntia* as an ethnomedicine is reported in many sources (fully described in chapter ten). In block 100, *Opuntia* as medicine is congruent with the health condition of the man found in room 105. The potential associations of *Opuntia* include a seasonally specific milled cuisine, a flower cuisine, a medicine, and an association with ceremony and clan.

[42] Le Blanc (1999) describes *tchamahias* as a possible class of weaponry, "celt-shaped, ground stone objects. They seem to have been produced in the Four Corners area. They are made of soft stone, can vary in length, but 20-25 cm is typical. ...these objects have generally been considered farming implements (i.e., tips of digging sticks). It is clear that they were hafted (Morris 1939) and a case can be made that they were the stone tips of some type of weapon." He goes on to note, "historically, *tchamahias* presumably recovered from prehistoric contexts were used by Pueblo people in ritual contexts, and these contexts had some relationship to warfare ... the case to how and why they were used as weapons is not particularly convincing. *Tchamahias* were often made of soft stone—in particular hornstone—seemingly the exact opposite kind of stone that would be used for a weapon ... Rohn (1971) makes a good case that the argument for their use as digging implements is also weak" (116). Ethnographic records describe in detail the use of the soft stone of the ancient Pueblo people in ceremony and religion.

The same interpretative challenges related to *Opuntia* remains are apparent for inferences of maize use. The apparent absence of maize at the time of attack (ca. A.D. 1277) has been associated typically with maize harvest declines and subsistence stress. Quantifying abundance, "lack of" or "absence of" maize is compounded by the expected grinding of maize for the making of flour and meal. Mealing rooms and grinding/metate bins are indicators that maize and other foods were processed for the purpose of making flour and meal. Fragmentation caused by grinding removes clearly definitive maize characteristics creating a situation where a clear identification is often impossible although suspected. The requirements of reasonably genera-specific identification force an interpretation of "tissues, unknown" making maize analytically invisible. (I've attempted to identify maize epidermal tissue in Appendix A). Once entered into a database, these fragments become even less visible in reporting. The "loss" of processed maize is a serious interpretative loss and continues to be an unresolved problem. The analysis of maize pollen does not capture the information in the way we would like, the tightly arranged leaves that enclose maize limits pollen recovery on grinding tools. The expected processing of maize would reduce the majority of its characteristics to "powder" (see Cushing 1920; Kennard 1979).

<u>Block 100 residents: disease and dis-ease</u>

Who were the people of block 100? Their health tells us a great deal about their lives. Of the five individuals whose remains were inadvertently encountered in block 100, three show evidence of debilitating, unresolved and unresolvable health issues. Predominant health conditions include the evidence of systemic disease (undiagnosed), porotic hyperostosis, and bone and teeth abnormalities (Kuckelman and Martin 2007). A robust 40-45 year old man (Human Remains Occurrence [HRO] 2) found on the floor of room 105 is notable for a diseased maxilla and a large perforation in his upper palate reflecting either a severe abscess or localized cancer (Kuckelman and Martin 2007:para.40). His skeletal structure is also unusual, in terms of both disease and congenital abnormalities. Of significance to my analysis, this individual also had six toes on his right foot, with the fifth toe bifurcated, a condition known as right postaxial foot polydactyly. This abnormality is associated with a number of congenital syndromes. Bifid and fully formed extra digits are linked to separate genetic phenotypes (Zhao et al. 2002:162). The condition has been noted in skeletal remains found in room 330 at Pueblo Bonito. Rock art on the cliff behind the building show a footprint with a fully formed extra digit on the right foot (Barnes 1994; Kuckelman and Martin 2007:para.82). In addition, his skull was pitted with lesions indicative of porotic hyperostosis (or "PH"), a condition he shared with his younger relative (HRO 3), an inferred daughter or niece whose remains were found in kiva 107 (para. 44).

Porotic hyperostosis

PH is a condition that causes thickening and porosity of the skull around the eyes and is a characteristic of the body's response to an array of contributing factors that result in anemia (Rothschild 2012; Walker et al. 2009). A "synergistic" combination of nutritionally poor diet, infection, and unsanitary living conditions leading to bacterial infections are part of the spectrum of this disease (114). The condition was not active in these individuals or in others at SCP at time of death and was the result of prior episodes of anemia. Three young individuals found in block 1000 (an adolescent of approximately 12-15 years of age, a probably male of 20 years of age, and a probably female of 15-20 years of age) also likely related to these two, also shared a history of PH.

Reinhard (1992; 2008:89) makes a case for a connection between the prevalence of PH and widespread internal parasitism in Ancestral Pueblo communities:

> The prevalence of pinworm parasitism covaried with porotic hyperostosis prevalence at ancestral Pueblo sites where both coprolite and skeletons were studied. Porotic hyperostosis is an indicator of general skeletal pathology that has been used to assess maternal-infant health. The fact that these indicators of disease had a positive, statistically significant correlation underscores the use of pinworms as a general gauge of ancestral Puebloan disease state.[43]

Stuart-Macadam (1992) writes that the PH diagnosis has been inferred archaeologically as a reflection of those groups "who have been considered to be less successful in adapting to their environment or are more nutritionally disadvantaged than other groups," which is an inaccurate characterization. The physiological response to microorganism infection decreases the body's ability to absorb iron thus creating conditions less amenable for bacteria to flourish, while in the process, causing iron deficiency in the host. In their analysis of PH in children, Walker et al. (2009) note that PH lesions reflect vitamin B_{12} deficiency anemias caused by "inadequate diets, poor sanitation, infectious disease and cultural practices related to pregnancy and breast-feeding" (114). These are anemias that are the result of the destruction of red blood cells, not iron-deficiency *per se*. Without sufficient red blood cells, iron deficiency naturally follows. Inactive PH not only reflects the infectious response shown

[43] Reinhard (1992:252) makes the argument that, "if pinworm parasitism is viewed as a gauge of microparasitic infectious disease [protozoal, bacterial and viral infection], then the high correlation of pinworm prevalence in coprolites and porotic hyperostosis prevalence in crania could implicate microparasitic infections as a causal factor. This indicates that protozoal and bacterial infections by species transmitted in conditions of poor hygiene, poor sanitation, and crowding had a causal relationship with anemia. The organisms most likely involved are those that cause diarrhea (Kent 1986)." Evidence of inactive PH in the crania of residents in block 100 and 1000 suggests that at one time they either contracted the disease elsewhere or contracted it at Sand Canyon Pueblo where it resolved.

by Reinhard (2008) and Stuart-Macadam (1992), but it can also be the result of chronic diarrheal disease due to infected water sources. In very young children, PH may be due to “weanling diarrhea syndrome” caused by low infant nutritional intake due to prolonged breast-feeding from nutritionally compromised mothers but it can also occur because of the weaning stage, a stage sometimes characterized as “the nutritionally inadequate, bacteriologically unsafe environments children are often exposed to during weaning” (Walker et al. 2009:115). (Crawling around on floors comes to mind.) The PH diagnosis and its etiology are important for considering resource stress, raiding and “famine.” The disease was inactive prior to A.D. 1277 and therefore, conditions were improved enough to halt the progression of the disease, anemia and diarrhea must have ceased to be a problem. PH resolved because Sand Canyon Pueblo living was better in the late 13th century even if the living arrangements were crowded.

In addition to the PH diagnosis, congenital polydactyly and a perforated palate, the robust man in room 105 had unusual skeletal manifestations. His right clavicle was abnormally enlarged and his arm bones were abnormally flared. He suffered from osteoarthritis, lacking muscle attachment in the hips possibly due to time spent sitting with his legs extended, working in stone in the making of tools or other implements (Kuckelman and Martin 2007:para.58-61). He had hypodontia (pegged and anomalous teeth).[44] Certainly his appearance would have been somewhat unusual. The architecture and artifacts of the block provide additional information about the life of this individual. An adjacent room (structure 104) contained an uncommon abundance of two-hand manos (18) and slab metates (6). Many more manos were found in the three kivas of the block along with a quantity of single-bitted stone axes. Compared with other blocks, these artifacts are not necessarily unusual but their quantity is. Ground stone tools are abundant and toolmakers apparently reside in a number of architectural blocks. The most pressing concern for this individual, however, would likely have been the mitigation of pain and eating. His occupation served to exacerbate joint and muscle problems but his perforated palate would have created some urgency. This medical reality is mirrored by the skeletal evidence of abnormality in HRO 3, who, based on her condition, suffered considerable disadvantages also.

Periostitis

The skeletal remains of a frail young woman (HRO 3), estimated age 18-20 years, was found in rectangular kiva 107, a structure connected to tower 101. The kiva contained a collection of plants similar to that of the tower, many notable for pharmacological activity. The young woman suffered

[44] Pegged teeth look like small cones. Hypodontia is congenitally missing teeth and both conditions are genetically linked to polydactyly (Kuckelman and Martin 2007) and other syndromes. The older man was noted to have hypodontia, as did the young woman.

from a variety of severe health issues during her short life that no doubt necessitated the need for medicinal plants. These included inactive PH. She also suffered from periostitis of the long bones, thought to have been the result of a systemic disease. Kuckelman and Martin (2007) suggest that this was most likely from bacterial infection. Acute periostitis is chronic inflammation characterized by extreme pain, although less extreme forms can occur, sometimes caused by trauma. In infancy, periostitis develops as a result of congenital syphilis infection (Friedman 1958). An infant (HRO 1) found in nearby midden (midden 103) showed evidence of periostitis, as did others formally buried in room 1017 in block 1000. These included a late-term fetus (HRO 9), an infant of approximately one year of age (HRO 15), and, an adolescent around 12-15 years old (HRO 19). Early infant mortality, particularly fetal death due to congenital syphilis, is well documented (Whipple and Dunham 1938).

Syphilis or treponemal disease is a physically devastating infection caused by the treponemal spirochete and is the subject of contentious debate as to origins. What is less commonly known is that syphilis is one of four variants that include pinta (*Treponema carateum*), yaws *(T. pallidum pertenue*), treponarid or bejel, also called endemic syphilis (*T. pallidum endemicum*), and venereal syphilis *(T. pallidum pallidum*). All are marked by a similar disease trajectory where skin, bone and cartilage are involved (Marks et al. 2014). The non-venereal variant, pinta, does not affect bone. Yaws, also non-venereal, and seen today in hot and usually humid areas, affects bone and is characterized by highly infectious skin lesions occurring during the early years of life (between two and ten years of age). Yaws is of most concern today as it appears to the most prevalent (603). Meyer et al. (2002:44) report osteological changes in the bones, hands, feet, fibula, clavicle, femur and ulna particularly in late stage yaws infection. A condition known as "saber shins" is commonly associated with yaws, as is a bowing of the tibia called "boomerang leg" and crater-like lesions in the crania. Destruction of the soft tissue around the nose and palate can destroy underlying bone and cause disfigurement. Endemic syphilis (Bejel), also non-venereal, occurs today in drier hot climates and causes inflammation and bone changes only in the later stages of the disease. Like yaws, it affects mostly children between the ages of two and ten again due to physical contact with skin lesions. In its advanced stages is characterized, too, by periostitis, destruction of the nasal area and soft gummy tumours or "gummas," and gangosa, a destructive ulceration of the nose, nasopharynx and hard palate causing perforation (Meyer et al 2002:44-45). Nonvenereal variants of treponemal disease may be indistinguishable from venereal syphilis. Bone changes are particularly aggressive in venereal syphilis, which also infects internal organs and the nervous system. In unborn children, the disease crosses the placental barrier causing periostitis, dactylitis (inflammation of the digits seen in a variety of diseases including tuberculosis of the bone and joints and also seen in yaws [Olivieri et al. 2006:334-335]). At this stage, two outcomes of the disease occur: 1) fatality in the fetal or newborn stage, or 2) appearance of signs over the first two decades of life (Woods 2005:249). Additional complications include distinct abnormalities of the permanent teeth, such as Hutchinson's incisors, small peg-like teeth distinguished by notches (Meyer et al. 2002:46-47). Disturbing signs of late congenital syphilis include short or protruding mandible, high-arched palate, saber shins, flaring scapulas and bilateral knee effusions (Hollier and Cox 1998). The development of significant swelling and inflammatory change produces considerable pain and inability to flex the knee (Anderson 2006:196).[45] Neurological signs could include mental retardation, deafness, and hydrocephalus. These manifestations would have marked people as ill, certainly different, and potentially dangerous.

Non-venereal treponemal variants today generally affect poor, rural communities and occurrence is most prevalent in developing countries (Woods 2005). However, the disease has been present around the globe in some form, for at least several thousand years. Treponemal bone changes are seen in 2,500 - 3,000 year old human remains from Siberia, Peru, Central America, Puerto Rico and the Mississippi area (Rothschild and Heathcote 1993:198). Rothschild and Rothschild (2000) report that skeletal evidence from the Colorado Plateau demonstrates a pattern of transmutation of yaws to venereal syphilis approximately 2000 years ago; the transition to crowded village life from the more mobile lifestyles of smaller groups that occurred in Basketmaker times likely contributed to its spread and, potentially, its evolution. This period was also associated with the onset of one of the many severe drought cycles noted for the southwest (152). The ecological zones associated with yaws (hot and humid) and bejel (hot and dry) add controversy regarding its origins and development. Certainly, the occurrence of a long period of drought and increased numbers of people, especially children, living in close proximity would create conditions amenable to the transmission of many infectious diseases.

HRO 2 also had extreme cranial deformation, hundreds of wormian bones (lambdoidal suture) in addition to thin, curved and porous long bones. Kuckelman and Martin (2007) indicate this may be a form of osteogenesis imperfecta or poliomyelitis. (Wormian bones are known to occur as a result of trauma and a variety of bone dysplasias [para. 51; Marti et al. 2013]).[46] Osteogenesis

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[45] Dental abnormalities include peg-shaped upper incisors (Hutchinsons), mulberry molars and perioral fissures. Mulberry molars are congenital malformation of the first molars characterized by hypertrophy of the enamel. Enamel on the upper surface of the molar looks like clusters of rounded projections. Deep lines around the mouth as seen in perioral fissures are one of the characteristics of congenital syphilis.

[46] Recent investigations into unexplained fractures in a normal population of 320 children found that bone dysplasias, congenital hypothyroidism, rickets and "above all osteogenesis imperfecta" were the cause of wormian bones in the absence of trauma. Researchers also concluded that wormian bones are very common in normal populations and should be considered a simple anatomical variant that is poorly understood (Marti et al. 2013). Obladen (2012) reports that culturally deformed skulls exhibit wormian bones significantly more often and that cradleboarding typical of Southwestern groups enhances this condition.

imperfecta, also known as brittle bone or Lobstein's disease is associated with shortening of the long bones and characterized by short stature amongst other skeletal defects. Estimates of the young woman's height are inconsistent with the condition. Like her older male relative, she was estimated as one of the two tallest individuals of those who could be assessed for height.[47]

In addition to her malformed skull, her chin was markedly pointed. She shares this feature with the young woman (estimate age 17-26 years) whose scattered remains were found in kiva 108. It is likely that they, too, are related (Kuckelman and Martin 2007:para 72). Gay et al. (1990) document a bird-shaped face, cranial distortion and extensive wormian bones in Hallermann-Streiff syndrome, (also notable for blue sclerae and dental anomalies). Short stature is a hallmark if the condition. If her condition was poliomyelitis complications of the disease might have included, in no particular order, pneumonia, problems with movement, lung problems, myocarditis, loss of intestinal function, permanent muscle paralysis, deformity of bone, pulmonary edema, and urinary tract infections (Vyas 2013). Unusual face shape is also noted for advanced treponemal disease: the mandible shortens and protrudes, saber shins occur, and the palate becomes highly arched (Hollier and Cox 1998).

Whatever the cause or causes, like her older male relative, the young woman was clearly debilitated. An absence of any occupational stress markers and little muscle attachment indicates that this young woman did not work, or could not work at labour-intensive activities (Kuckelman and Martin 2007). Strategies to deal with pain and inflammation were certainly indicated. Regardless of its origins, disease is a distinguishing feature of some of the people who perished in blocks 100 and 1000.

Block 100: medicinal plants

"Plant medicine is a form of power," writes Parsons (1996 [1939]:189) and powerful knowledge was a contributing factor in the acceptance of new clans into historic villages (Whiteley 1998). The fact that little is written about particular plants is a clue to their cultural significance and controlled use. A review of current phytochemical and pharmacological research demonstrates that historic Puebloans were well aware of medicinal efficacy of particular plants and in some cases guarded that knowledge from the uninitiated. *Cleome,* so apparently unique to samples from block 100 is, like other genera of the Capparaceae (Caper) family, effective for its analgesic, antimicrobial, antifungal, antioxidant,

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[47] It is interesting that other congenital abnormalities associated with osteogensis imperfecta include preaxial and postaxial polydactyly (IAME 2015). However, postaxial polydactyly and dental abnormalities are also linked with other syndromes such as Ellis-van Creveld syndrome, a type of dwarfism with hypodontia and mandibular anomalies, both diseases mapped to the same chromosome (Howard et al. 1997). If she did suffer from brittle bone disease, her condition was likely accompanied by other co-occurring abnormalities such as deafness, blue sclera (sometimes extremely pigmented), translucent skin, bone fractures and mental deficits. All would have marked her, like her close relative, as substantially "different" in appearance.

antirheumatic and cytotoxic activity (Albarello et al. 2006; Ladhari et al. 2014; Narendhirakannan et al. 2005; Narendhirakannan et al. 2007; Tsai et al. 2012). *Cleome serrulata* (beeweed) a wild plant, was semi-cultivated by the Hopi, suggesting its importance (Whiting 1939:17) as a food (greens), an ingredient in black dyes (Hough 1897), and as a medicine. Additional evidence suggests that *Cleome* was of particular interest to the residents of block 100.

<u>Block 100: symbolic content and material culture</u>

An effigy, a unique rectangular pottery box, and rock art unique to block 100 can be explained through ethnographic analogy. These identify the residents as a particular group of people. Features and configurations in the block lend weight to my assessment that a very specific group of people residing in this location.

Identity markers: The bear effigy, polydactyly, and acts of transformation

Tower 101 is unusual for a number of features. The most significant is an effigy described as resembling a "lamb's" or "sheep's" head (CCAC 2004; Kuckelman 2007). Made of sandstone the sculpture resembles a contemporary domesticated lamb (CCAC 2004; Kuckelman 2007) although its facial characteristics are distinctly unlike that of either a mature or immature mountain sheep. It does however, accurately reproduce *Honaü*, the Bear figure from the west wall of the Warrior's Room at Walpi Pueblo on the Hopi Mesas as reported and drawn by Fewkes (1902: plate XXII). Waters (1977:340) records *Hónaw* as Bear, *Honnyam* as Bear Clan (344). Hopi hereditary chief, Edmund Nequatewa (as told to Alfred Whiting in 1942 [Seaman 1993:14]), reported that Bear Clan people "were always the head of the towns in Hopi country."[48] This leadership role is confirmed in other ethnographic sources (Cushing 1920; Parsons 1996 [1939]; Whiteley 1998). I have adapted selections from Peter Whiteley's (1998) Hopi ethnography regarding the mythology of the Bear Clan that have clear significance to Sand Canyon Pueblo:

Orayvi, the first Hopi village, is located on Third Mesa (Arizona). Its history and origins reinforce the potent power of the Bear clan. Until the 20th century, Orayvi (spelled Oraibi in older literature) was the largest Hopi village and home to half of the Hopi population in 1900. Inhabited since at least 1150 C.E., it holds the distinction of being the oldest and continuously occupied village in North America (Whiteley 1998:85). After their Emergence into the Fourth (and contemporary) World, the Bear clan migrated to Orayvi. The Bear clan leader held the power to accept or turn away

[48] Waters (1977:345) records *Yahoya* as the deity of Bear Clan at Shongopovi (Hopi second mesa village). According to Water's ethnography, the Bear Clan led the migrations of the Hopi people to the northwest finally settling at the second and third mesa villages of Shongopovi, Oraibi (Orayvi), Mishongovi, Shipaulovi (47, 84,119), Arizona. The northwest location of block 100, the Bear effigy and Bear Clan associations have interesting connotations for the interpretation of the tower and the block.

any other clan unless the clan could prove, through ceremonial display that they had special powers, described in contemporary terms as, "socially valued knowledge" (60, 94, 114). Of particular concern was the ability to mitigate environmental conditions.

The effigy found in the fill of the tower was interpreted as likely projecting from the wall (CCAC 2004: Rooms, Structure 101). The ethnographic record of bear effigies situates ownership in the Bear clan. Parsons (1996 [1939]:189; emphasis added, footnotes and other notations from this author included) provides ethnographic evidence for the importance of the bear in a medical context:

> Animals are the givers of medicinal plants which are named for them, as, for example, the root which is called lion medicine or the root of aster (*ericae* [sic] *folius* Rothrock) famous as "bear medicine"*
>
> Of all the curing societies, Keresan, Zuni, or Tewan, Bear is the particular patron. The doctors or shamans are called bears;† by drawing on the bear paws that lie on the altar the shamans impersonate bears; the paw is the equivalent of the mask. It is believed that shamans have power literally to turn into bears, just as bears may divest themselves of their skins and become people. Bears and bear shamans, they who "can call the Bear" (Zuni), carry on their ceremonies jointly, the bears visiting the ceremonies of the societies and after death the shamans going to live with their bear colleagues.
>
> * Stephen 4[1936]:863, n.1. The Cochiti hunter rubs on himself as a strength-giving tonic the root of an unidentified plant called lion medicine (Goldfrank 3[1927]:85; Stevenson 2 [1904]:576). This is used by the Cactus war society of Zuni. All this is close to the widespread concept of getting power from animals or plants. *Plant medicine is a form of power*.
>
> †The members of Zuni curing societies are called "animals"; the chiefs are White Bear, Wildcat, Mountain Lion (Benedict 3[1935]:I, 64); cf. p. 232.

"Bear medicine," she writes, "used by all curing societies, induces a trancelike state in the doctor during which he can see the witch causing the sickness" (Parsons 1996 [1939]:414).

Stone images of clan animals are considered by the Zuni, Hopi and others to be guardians or protectors and "formerly offered prayer-sticks ... [and] always prominent on altars" (Parsons 1996 [1939]:188). Effigies were considered not considered simply prey animals, but mediators in curing societies, providing medicinal plants that are named for them (189).[49] The Bear, Wildcat, Mountain Lion combination and their associations with medicine in Parson's notes are also represented on the walls of the Warrior's Room at Walpi (Fewkes 1902: Plate XXII that feature Mountain-lion [north],

[49] *Ericae folius* Rothrock is identified as "Bear Medicine" (189). Today the plant is classified as *Chaetopappa ericoides* (Torr.) G.L. Nesom, a native species to the lower 48 States (USDA NRCS 2015) and a member of the Aster family, commonly known as rose heath, a small white daisy. As an ethnomedicine, *C. ericoides* was a universal drug for a variety of ailments and conditions for historic Pueblo groups and was specifically used as a sedative, stimulant, analgesic, antirheumatic and anti-inflammatory medicine (Stevenson 1915; Weber and Seaman 1985:248; Whiting 1939).

Bear [west], Wildcat [south] and Wolf [east]). In contemporary society, "Bear Clan members become village *kikmongwis* [the main leaders] at the Hopi villages" (Trimble 1993:57). The Bear features prominently in Zuni religion, like the Hopi, associated with the west and the colour blue. *Ne'-we-kwe,* the "Band of Wise Medicine Men" (Cushing 1920) of the historic Zuni resonates in this block also, among Tewa societies Bear medicine is owned by the Flint and Fire societies (Parson 1996 [1939]:133).

The connection to headmen, clans and "elites" has resonance in block 100 more obviously so than elsewhere because of the effigy and human remains. Whiteley (1998:86-87) clarifies the concept of Hopi elite. Within the social order of contemporary Hopi society, the Bear clan is of significant influence.

> The cardinal division [in the Hopi class system if it could be called such] is between *pavansinom* and *sukavungsinom*. *Sinom* means 'persons' or 'people.' *Pavan* has a broad semantic field, but in this context may be rendered as 'most powerful' or 'most important.' ... The English glosses Hopis usually give for *sukavungsinom,* namely 'grass-roots people,' 'common people.' Correlatively, *pavansinom* is usually glossed 'ruling people.' Although Hopis can and do identify individuals who are *pavansinom* on a regular basis, criteria for the occupancy of this category are more complex... While there is a sense in which all members of the Bear clan are *pavansinom* in comparison, say to the Sun clan, the distinctions can also be made *within* the Bear clan ... those members of the Bear clan in the core lineage segment that provides the *Kikmongwi*, or 'village chief,' own the *Soyalangw,* 'Winter Solstices,' ceremony; provide the officers for it; and are the *pas*, 'real,' *pavasinom* within the Bear clan. Other members of the Bear clan may be regarded, from this perspective, as *sukavungsinom.*

Moreover,

> 'Whenever the statement is made that a certain office or ceremonial privilege belongs to a clan, concrete data always show that transmission is, above all, within the narrow circle of actual blood-kin and only secondarily extends to unrelated clansmen' (Lowie 1929:330 in Whiteley 1998:69-70).

The six-toed man who died in room 105 could have been not only a craftsman in the traditional sense, but an influential knowledge holder. If the echoes of Chaco are socially as powerful at Sand Canyon, this man's power may reside in his foot abnormality and sophisticated knowledge of curing plants, reinforced by a metaphoric connection with Chacoan elites and association with a bear effigy and its metaphoric content suggestive of transformation and power. Certainly his debilitated health created some urgency for curing, demanding a comprehensive selection of medicines. His six toes not only hint at genetic links to Chaco, but also with the mythical and transformative figure of the bear as demonstrated in the petroglyphs of Newspaper Rock, near Moab, Utah. More than one set of six-toed human footprints walk among and with, the tracks of bears (Figures 6.4, 6.5 and 6.6, pp.

173-174). The metaphoric potency of "man" and "bear" is further illustrated by Parsons (1996 [1939]: selections from pp. 134-135; emphasis added):

> The medicine order [of curing societies specifically Zuni, and the Rio Grande Pueblos of Cochiti, Sia and Jemez] is the superior order; but even in it only certain individuals, more particularly the chief, conduct cures. Analogously, in the undifferentiated Hopi societies the chiefs only are doctors. The society chief, possibly the medicine chief, will be called upon to cure whatever disease is associated with the society (134). When the one to be 'saved' is very ill or wishes to become a member of the society, the society will come in a body to his house, for four nights (Zuni from midnight to dawn), holding their most elaborate ritual, on the conclusive night, or on the fourth night the patient may be taken to the room of the society for the treatment or initiation that all have been four days preparing for. At this time the doctors impersonate the bears from who they get their power, '*they become bears,' chewing the bear root which gives them second sight*.

Newspaper Rock petroglyphs in Utah provide a glimpse of an ancestral story that suggests a metaphor of transformation, "getting power" from the bear. At least three sets of footprints pecked on the rock have six toes (one right-sided). The direction of walking is skyward, moving across the rock's expanse (Figures 6.4, 6.5 and 6.6, over).[50] In one example, a bear paw print has six toes (Figures 6.4, over).

[50] Newspaper Rock located outside the town of Moab, Utah, is a collection of 650 petroglyphs pecked onto a group of rock faces that include Ancestral Puebloan rock art, the oldest dated to approximately 100 B.C. – 1540 A.D. Included are recent imagery such as the representations of figures on horseback dated to the 1900s (from USDA Bureau of Land Management 2015).

Figure 6.4 Polydactyly and transformations in rock art: six-toed human footprints (lower left) and bear paw prints from a section of Newspaper Rock, Newspaper Rock National Historic Site, Utah. Photo: J. van Roggen (2009).

Figure 6.5 Six-toed footprints: Newspaper Rock National Historic Site, Utah, depicting left foot polydactyly (Type A, not bifid) and bilateral foot polydactyly. Photo: J. van Roggen (2009). It appears as if the walker acquires the condition as they move forward.

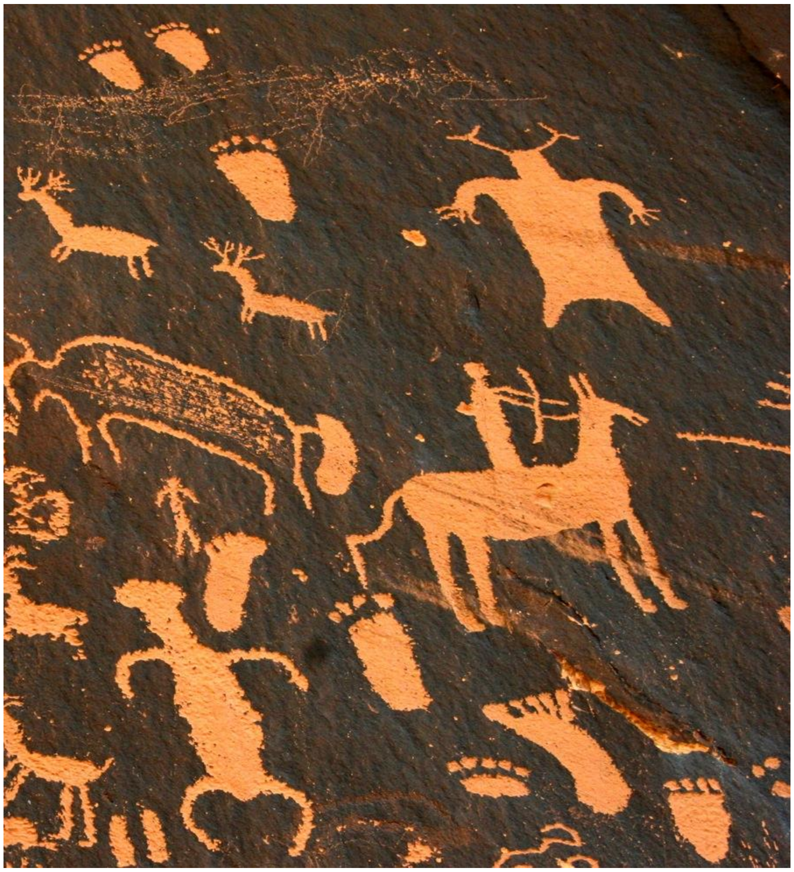

Figure 6.6 Human and bear walking. Newspaper Rock National Historic Site, Utah. Photo: J. van Roggen (2009). A five-toed human footprint can be seen walking with, or transforming into, bear prints. Photo enlarged from left side of the frame in Figure 6.4 (previous page).

Images on the Newspaper Rock panel include two sets of prints in close proximity, moving in the same direction, of bears walking. The front prints are squat and rounded, the hind prints simplified typical of black bear (*Ursus americanus*). Although black bear hind prints tend to appear foot-like with an "instep," these tracks are decidedly different than the companion prints that mimic an exaggerated human instep and the skeletal structure of the toes (lower pair, Figure 6.6). In the Newspaper Rock imagery, the human prints transform from a five-toed left foot to one of six toes in a single stride (the right foot displaying six also). Figure 6.5 shows two sets of prints, the bear-like tracks and the stylized human prints so suggestive of transformation. Other prints, some with five toes walk in tandem with bear tracks. In one set of images it appears that the "man," as he moves, disappears and bear tracks take his place. In this image the front print and hind print reflect the size difference expected of black bear, the shortened front print, in effect, "disappearing," the five-toed print becoming bear-like.

Dimensions and vectors of identity: the imagery of block 100

A concentric circle wall petroglyph/pictograph located over the firepit in tower 101 provides an additional reference to ideological imagery. Puebloan Emergence symbolism is cyclic, following a repeated pattern that Trimble categorizes as "the rhythm" of planting, harvesting, hunting, ceremonies, war, and curing, returning again and again in tune with the seasons (1993:54). The two concentric circles around a central "dot" located 90 cm above the floor is not Emergence symbolism so notably pecked on rock across the Four Corners. When viewed from the perspective of a concentric circle with a central star that decorates the south wall of the Warrior's Room at Walpi, there is a hint that a particular focus in the tower perhaps alluding to a partnership between groups. A Black-on-white bowl found at Yellow Jacket Pueblo has a similar dual circle/central dot design but one that is painted around the outside body of the bowl (CCAC 2015a:photograph number 7096). More than simply esthetics, concentric circles contain what Whiteley (1998) defines as "ideational complexes" so notable in Hopi language and thought. This imagery is not spiral, looping back and moving onward, it is fixed around a central theme.

Another unique image decorates a tiny rectangular Pueblo III White Painted pottery box. Found in room 104, it has a plant painted on its interior surface. The plant shares simplified characteristics such as the compound palmate leaves and budding head of *Cleome serrulata* Pursh. It mirrors Charles Shirley's drawing of a *Cleome* plant in Ruth Underhill's (1991[1946]) *Life in the Pueblos* (originally published in 1946 under the title, *Workaday Life of the Pueblos*). Underhill (1991[1946]:47) writes of *Cleome* that, it is "so important to the pueblos that it was sometimes mentioned in ceremonies, along with corn, beans and squash."[51] The simplified and stylized head (pre-flowering) and leaves do not compare to any other native Southwestern plant that I could identify. The *Cleome* image marks this box as particularly different, something associated with what Renfrew and Bahn (2004:221) describe as dimensions and vectors of identity. Two other boxes of rectangular shape were found under a kiva bench in subterranean kiva 501, neither have interior decoration and neither is so small. Cushing (1920:PL. XXVII, figure *l*) writes of a decorated

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[51] *Peritoma serrulatum* (Pursh) D.C. (Rocky Mountain Bee Plant) otherwise known of today as *Cleome serrulata* Pursh., is recorded by Stevenson (1915:96) as the Zuni word, *A'pitalu* translated as "hand many seeds," reflecting the hand-like appearance of the leaves and the quantity of seeds. "After boiling the entire plant in water for a long time, it is removed and the tea allowed to evaporate. The paste precipitated is used in conjunction with a black mineral paint to color sticks of plume offerings [prayer sticks] to the anthropic gods. The mineral is supposed to have been brought from the underworld when the Zuñi ascended to this world. *Polanisia trachysperma* Torr. & Gray (clammyweed) also from the Capparaceae (Caper) family is also given the same name ("hands many seeds"). *Polanisia* root and blossoms were used on the whipped Cactus fraternity participants as they return to their fraternity room after the "last dance in the plaza." In this case, the presence of flowers would preclude the dispersal of seeds and limit their recovery in archaeological contexts. Capparaceae species are known for their pharmacological activity.

rectangular box of spices present a midday meal at Zuni Pueblo (560). In the context of block 100, a spice box is a less plausible explanation. With so few of rectangular vessel types recorded and with such distinctive imagery, the box hints at the unusual. Alternative explanations can be found in the ethnobotanical record.

Kiva 108, a Pueblo II four-pilaster style kiva in block 100 is distinguished by symbolic decoration, the original kiva floor has a figure thought to represent *Kokopelli*[52] pecked and abraded into the bedrock below the final prepared surface of the floor (CCAC 2004). A shallow basin was pecked nearby that may have been connected to the figure (Kuckelman 2007b). Interesting for its symbolic value as a flute player, the image is also important for its deliberate "disappearance" when the floor of the kiva was plastered over.

Material correlates for the interpretation of study samples

I have outlined several lines of evidence in this chapter that have their ideological correlates in Pueblo cosmology. The archaeological correlates include distinctive imagery and configurations that are unique. The human remains provide compelling evidence of disease and difficult living challenges. The human remains found in blocks 100 and 1000 also demonstrate that the raid on Sand Canyon Pueblo ca. A.D. 1277 succeeded in killing the most vulnerable, infants, young children, adolescent, elders and those handicapped and debilitated. It is also clear to me that these individuals were not expecting the day to include warfare or terror. The plant remains in these contexts reflect assemblages seen from the earliest occupation until last days. Beyond the obvious problem of sampling for plant remains under the conditions of excess sediments and subsampling, interpretative value of flotation samples is undermined by inaccurate contextual data. Timing of deposition is critical.

Estimates of depositional timing for Sand Canyon Pueblo study samples

Dates of deposition are unclear for many samples and I have made some assumptions based on architectural construction and cultural behaviour. My estimates of temporal deposition of samples evaluated in the study are detailed in Table 6.7 (over). The samples indicated by shading are from ambiguous temporal contexts and the inferences of timing can be considered tentative. All other estimates are based on my best assessment considering the information available.

[52] Fowler (2011:209) describes *Kokopelli*, as the mythical "'hump-back flute player' who has seeds or other things in his hump (which may also be a burden basket). He seduces and impregnates young girls and is a general symbol of fertility. Rock art images of Kokopelli occur widely across the Southwest...He and a female counterpart are also kachina figures in Hopi ceremonies." In my analysis of Sand Canyon Pueblo I interpret the *Kokopelli* image as analogous to a Flute society identity.

Table 6.7 Estimates of temporal deposition for SCP study samples (shaded timing tentative).

Provenience	Sample number
Earliest construction and initial occupation (circa A.D. 1240s)	
Courtyard 513 refuse	SC10
Early ideological (circa A.D. 1250s)	
Midden 109 (see also A.D. 1270s)	SC6
Midden 209 (see also A.D. 1260s)	FV11/CV11a/CV11b
Midden 515	SC7/FV12/CV12
Courtyard 1000 refuse	FV15/CV15a/CV15b
Ideological expansion (circa A.D. 1260s)	
Midden 209 (see also A.D. 1260s)	FV11/CV11a/CV11b
Midden 515	SC7/FV12/CV12
Courtyard 1000 firepit (early A.D. 1260s)	SC1
Courtyard 1000 firepit (circa A.D. 1266)	FV3/CV3
Room 1005 firepit (late A.D. 1260s)	FV4/CV4
Room 1008 (tower) NW firepit (late A.D. 1260s)	FV5
Room 1008 (tower) SE firepit (late A.D. 1260s)	CV5
Kiva 1206 central hearth (after A.D. 1265)	FV10/CV10
D-shaped building plaza 1500 refuse (circa A.D. 1261)	FV16/CV16
D-shaped building bi-wall room 1507 refuse (see also A.D. 1270s)	CV18
Firepit, D-shaped building bi-wall room 1527	SC3 (see also A.D. 1270s)
Transitional (circa A.D. 1270s)	
Midden 109 (see also A.D. 1250s)	SC6
Kiva 517 central hearth	FV7/CV7
Great kiva 800 refuse	FV17/CV17
Midden 803	SC8/FV13/CV13a/CV13b
Kiva 1206 central hearth (after A.D. 1265)	FV10/CV10
Midden 1214	FV14/CV14/SC9
D-shaped building bi-wall room 1507 refuse (see also A.D. 1260s)	FV18
D-shaped building bi-wall room 1511 refuse	FV19/CV19
D-shaped building bi-wall room 1513	FV20/CV20
Catastrophic and post-catastrophic (circa A.D. 1277)	
Kiva 102 central hearth	SC4
Kiva 400 hearth	FV6/CV6
Room 1002 firepit	SC2
Room 1003 burned spot	FV2
Room 1008 (tower) burned spot	CV2
Kiva 1010 central hearth	FV9/CV9
Kiva 600 hearth (circa A.D. 1260s-1280s), lack of direct evidence of violence confuses a clear assessment of "latest" deposition. Violence noted in kiva 602 nearby	SC5
Kiva 601 hearth presumed "latest" based on violence in kiva 602 (see sample SC5)	FV8/CV8
Unknown/unclear (circa A.D. 1240/50s – 1280s)	
Burned spot Arb. Unit 1 outside wall, block 100	FV1
Burned spot Arb. Unit 1 outside wall, block 100	CV1a
Burned spot Arb. Unit 1 outside wall, block 100	CV1b
Burned spot Arb. Unit 1 outside wall, block 100	CV1c

Certain things are known about Sand Canyon Pueblo: there was a "before" and a dramatic "shift." The original "abandoned leisurely/abandoned violently" characterization of occupation fails only in its assumption that people took their possessions as proof they left before the final days, it does not account for the possibility that their possessions were taken by others (pillage as part of "war"). The attack may have included this goal and been well planned to achieve those ends. "Abandoned violently" certainly describes the events of the final days. Some thermal feature samples came from these violent contexts. The five-phase scheme I use here attempts to view evidence at a scale that allows differences in plant use to be understood more fully, linked to very specific phenomena. It is quite possible that the closest we can come to an archaeobotanical "deposition" is a "before things changed" versus "after things changed" and a "just prior to warfare."

Chapter summary

Sand Canyon Pueblo is different than other Pueblo III village in the Mesa Verde area of southwestern Colorado. Its architectural configurations demonstrate a version of a particular confluence of ideas. The language of the architecture has deep links with the earlier, powerful and massive architecture of Chaco Canyon, specifically Pueblo Bonito. The ideas embedded in the buildings appear to be co-opted or understood to reflect ideological values of Sand Canyon Pueblo. In the next chapter I review the various architectural blocks and describe the most cogent aspects of these excavation units to provide baseline data from which to assess the plant record, sampling adequacy, and interpretative potential of the plant remains and the site.

Chapter 7 Contextual synthesis: Sand Canyon Pueblo material culture

Chapter summary

My analysis of the archaeobotanical sampling effects is based on the original archaeobotanical record of Sand Canyon Pueblo (SCP). The identification of "representative" samples also rests on "representative" interpretation. This chapter serves to provide details of important site components and provides the background to my interpretation of a medicinal toolkit in block 100 and the presence of Warrior Brother cosmology at Sand Canyon Pueblo made visible through the wild plant record, the use of wild plants in curing, ceremony, and leadership roles in the historic and contemporary period, and the material culture of the site.

Background

The material culture of the various blocks and their most salient features are critical for assessing the archaeobotanical remains identified in Sand Canyon Pueblo flotation samples. As I will show the archaeobotany is also critical for interpretation of the site. I review the excavation units in some detail and this chapter serves as a reference for the results of my analysis and inferences. The site report (Kuckelman, ed. 2007) and CCAC databases contain additional information and detail (CCAC 2004, 2015a). My description of excavation units is ordered by architectural block. To appreciate the uniqueness of the individual architectural blocks and the site readers are strongly advised to access map links for clarity. As a referential strategy, I label the various units by their most salient features.

The data: Sand Canyon Pueblo excavation units in review

Architectural block 100 – the "Cleome" suite

Cleome (beeweed, beeplant, spiderflower) seeds are rarely identified at Sand Canyon Pueblo and have low visibility at other sites in the area. Block 100 is an exception. Rare remains are linked to subsistence reorganization at Sand Canyon Pueblo based on estimates of drought effects and the apparent abandonment and re-use of building materials presumably for fuel wood. I see a different strategy. "Rare" remains identified in Sand Canyon Pueblo flotation samples are linked through cosmological associations in Pueblo religion with medicine and war preparation. This is particularly true of those plant types identified as reflective of increased use of wild resources. These are *Cleome*, *Cycloloma atriplicifolium* (winged pigweed), *Lycium* (wolfberry), *Purshia tridentata* (antelope bitterbrush), *Penstemon* (penstemon), *Scirpus* (bulrush), all remains found either in late-latest occupation contexts or in association with unusual buildings. As outlined in chapter six, the *Cleome* suite as I have labeled block 100 is defined by its distinctive "rarity." Block 100 was occupied at the time of the final attack and it appears that the residents were unprepared for the final attack.

Tower 101: the "*bear effigy*" tower

Towers described as "circular and one to two stories in height," appear for the first time in the early Pueblo III period (Rohn 1989:159). Tower 101, estimated construction date ca. A.D. 1250s, was built in a D-shape abutting and protruding from the site-enclosing wall, an adaptation of the single circular tower notable on the general landscape of the area. Combined with a cliff edge of relatively imposing height, a protected water source, and tower "loop holes" (CCAC 2004: Rooms, Structure 101) used for sighting and monitoring activity outside the village, SCP construction seems to reflect the "more pressing defensive solutions" required in Pueblo III times (LeBlanc 1999:216). Defensive for certain, tower 101 is interesting for its esthetics. The bear head effigy points to a leadership role. The significance of the artifact, "a head," and historic clan associations with "headmen" is intriguing for interpretations of tower 101.[53] Muir (1999, 2007) interpreted SCP towers as spaces where activities around the organization of hunts and distribution of meat occurred. A similar faunal assemblage occurs in tower 101's eastern counterpart—tower 1008/1019 where similar big game remains were recovered providing evidence that perhaps a sharing of meat occurred between the two blocks ca. A.D. 1277. This would not be an unreasonable event if the two areas shared familial connections as suggested by Kuckelman and Martin (2007) and Lipe (2002). The bear head effigy of tower 101 provides durable evidence of a focus for tower 101 that in Pueblo history is one of a significant leadership role.

Effigies, guardian animals and social roles

Parsons (1996 [1939]:188) notes that stone images of important guardian or protector animals are always prominent on Pueblo altars. An altar was proposed for one of the two entryways noted for the tower (CCAC 2004: Kivas, Structure 107) consisting of a large platform situated in front of the entry that took up space in the northwest corner of kiva 107. The other entry into the tower was remodeled into a niche, another feature notable for storing effigies (Fewkes 1902). Six effigies have also been found in Sand Canyon Locality sites: three are described as animal heads (site 5MT5152), one a small bird head found at Yellow Jacket Pueblo (site 5MT5), the largest and longest occupied Pueblo III site

[53] The metaphorical importance of "heads" can be seen in many tribal hunting societies where the head of the hunted animal goes to the village headman who arranges for the culturally prescribed distribution of meat (Dods 1979). The assemblage of large game animals found at Sand Canyon Pueblo in latest occupation contexts explored through ethnographic analogy presages the historic distribution of meat in Pueblo tradition, the hunter gets the head, but very specific parts are apportioned (Muir 2007:103). The discard of certain bones is ritualized through placement of some on roofs and the burying of heads outside the village; the apparent scattering of bones on roofs at SCP shares similarities with traditional practice (103).

in the area (CCAC 2015a). Rooms and altars were historically places for preparation and foci for ritual and ceremony. Fewkes (1902:483-485) offers some insights that may enhance our understanding of SCP towers. Writing of the war festivals of "true Hopi" pueblos, Fewkes describes war ceremonies as events that occur on three different days:

> First day: A preliminary informal gathering of the chiefs who engage in a ceremonial smoke and make certain prayer-objects.
>
> Second day: A formal meeting of all the members of the fraternity for the purpose of manufacturing more elaborate prayer symbols, at which idols and sacred objects owned by the society are arranged in a prescribed manner on the floor of a room set apart for this purpose; prayers and rites before them make up the secret rites of the festival.
>
> Third day: A public dance of the warriors in the streets and the plaza of Walpi, when the participants, bearing the weapons of war and characteristically painted, perform in the presence of spectators.

The arrangement of the Warrior Room at Walpi was designed for such ceremonial preparation (Fewkes 1902). While archaeological and historical practices might differ, an underlying ideology of animals ("heads") and headmen in addition to activities such as the making of prayer-sticks ("*pahos*") and effigies has important inference potential for the use of rooms and towers at SCP. The plant remains in such locations could include certain wood types for the construction of such things, unusual wood types in firepits that could be the result of manufacture rather than fuel. *Populus* (cottonwood), *Salix* (willow), and *Quercus* (oak) are historic examples of woods used to make such objects (Moerman 1998), evidence of these wood types is not commonly found at SCP. Feathers of particular species of birds adorn prayer sticks. Muir (2007:para. 60-64) makes a case for the uncommon bird remains as potential evidence of prayer sticks (also called "rain birds") and associated ceremony in towers. An assemblage of uncommon bird remains was identified in block 100's midden (103) that are not suggestive of the remains of food. These were identified as Falconiformes (vultures/hawks/eagles), *Corvus corax* (raven), Passeriformes (perching birds), *Zenaida macroura* (mourning dove), *Branta canadensis* (Canada goose) and *Grus canadensis* (sandhill crane)(CCAC 2004: Structure 101, Animal Bone Analysis Summary), all notable for their association with ceremony and ritual. Block 1000 and the D-shaped building block (1500) also contained evidence of uncommon birds (Muir 1999; 2007). Sandhill crane remains are particularly intriguing in the tower. Cushing (1920:29-30) documents Zuni Emergence narrative originally recorded between 1879 and 1884 where a connection is made between the Bear and Sandhill Crane clans:

> Already before men came forth from the lower worlds [the First, Second, Third Worlds of Pueblo cosmology] with the priest-chiefs, there were many gods and

> strange beings. The gods gave to the priests many treasures and instructions, but the people knew not yet the meaning of either. Thus were first taught our ancients [sic] incantations, rituals, and sacred talks (prayer), each band of them according to its usefulness. These bands were, the "Priesthood" (*Shi'-wa-na-kwe*), the "Hunter-band" (*Sa'-ni-a-k'ia-kwe*), the "Knife-band" (*A'tchi-a-k'ia-kwe* or Warrior), and the *Ne'-we-kwe*, or Band of Wise Medicine Men.[54] The leaders of each band thus came to have wonderful knowledge and power - even as that of the gods! They summoned a great council of their children—for they were called the "Fathers of the People"—and asked them to choose such things as they would have for special ownership or use. Some chose the macaw, the eagle, or the turkey; others chose the deer, bear, or coyote; others the seeds of earth, or *a'tâ-a*, the spring vine, tobacco, and the plants of medicine, the yellow-wood and many other things. Thus it came about that they and their brothers and sisters and their children, even unto the present day, were named after the things they chose in the days when all was new, and thus was divided our nation into many clans (*a'-no-ti-we*) of brothers and sisters who may not marry one another but from one to the other. To some of the elders of these bands and clans were given some thing, which should be, above all other things, precious. For instance, the clans of the Bear and Crane were given the *mu'-et-ton-ne*, or medicine seed of hail and snow. For does not the bear go into his den, and appears not the crane when come the storms of hail and snow?
>
> When more than one clan possessed one of these magic medicines, they formed a secret society, like the first four, for its keeping and use. Thus the Bear and Crane peoples became the "Holders of the Wand" – who bring the snow of winter and are potent to cure the diseases that come with them.

The location of blocks 100 and 1000 as "gateways," in Sand Canyon Pueblo, if indeed that is what they were, is consistent with the notion of gateways, acceptance, and headmen. The architectural record of the tower provides additional clues. The placement of the concentric circle design above the firepit in tower 101 and the presence of two niches[55] presumably served for storage and display of ritual paraphernalia similar to historical clan rooms. The last use of the tower is captured in the firepit content. Based on fragments, *Zea mays* (maize/corn) was prepared in considerable quantity here. The wild plant remains captured through flotation samples consist of seeds of *Cleome* (beeweed/beeplant), Cyperaceae (Sedge family), Poaceae (Grass family), cheno-am (*Chenopodium/Amaranthus*), and two varieties of cactus seeds: *Opuntia* (prickly pear-type) and *Mammillaria* (pincushion-type)—a cactus

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[54] Later Cushing (1920:620) refers to *Ne'-we-kwe* as clowns or "Gluttons" "when they appear in public and the most sacred personages when gathered in secret councils. They are the medicine-men *par excellence* of the tribe, whose special province is the cure of all diseases of the stomach." Hieb (1972:176-180) outlines the oppositions and categories of mediation between the Zuni gods and the reality of Zuni material world: *Koko,* the God "as it should be," *Koyemci* the World "as it should not be," the Priests "as it should become", the *Newekwe* "the trickster" or the World "as it is." In the performance these categories are contrasted, demonstrating harmony of equality and the reversal, the Wise Medicine Men who consume powerful plants that cure and the gluttonous clowns who simply consume.

[55] Kuckelman (2007b: para. 13) reports the wall niches suggest ritual activities in addition to domestic activities occurred in kivas and other buildings at Sand Canyon Pueblo.

type not identified elsewhere. The last activity apparently consisting of a meal of corn meal or flour and a variety of wild plants either for seeds or other parts or a combination of both. A sealed ashpit in the tower contained similar evidence from previous use. This collection is typical of a pre-harvest milled maize cuisine (Sutton and Reinhard 1995).

Rectangular kiva 107: the "*religious room*"

Leaving tower 101 and entering kiva 107 requires crossing a raised sill doorway and a large platform (altar?) situated in front of the doorway. The platform and the shape of kiva are unusual, the space originally interpreted as a "religious room" (Adams, E., 1985a, 1985b; Scott and Aasen 1985). Although rectangular in plan, the kiva contains typical kiva elements, a ventilation system and recess (14), niches (three) and a typical pass-through (plugged). A floor pit made of a Mesa Verde Corrugated jar was located in the recessed southeast corner of the room. An unidentified three-legged zoomorphic figure is pecked on the west wall (the west direction being historically associated with the Bear [Fewkes 1902]). Similar plant remains and pollen types were identified in kiva 107 as those found in the tower (Scott and Aasen 1985). The west wall niche is significant for its unique abundance of *Artemisia* seeds, a collection of over 2,000 specimens (18). No such quantity has been found elsewhere at SCP or at any other sites in the Sand Canyon Locality.

The niche also held uncharred *Mentzelia* and Malvaceae seeds and an abundance of goosefoot/amaranthus-type ("cheno-am") seeds yielding a non-typical count of 450 cheno-am specimens. Only here and in blocks 1000 and 1500 are there counts anywhere near this quantity. The use of *Chenopodium* plants for antihelminth activity has a long history in the American Southwest and around the world (Trease 1935:290-291). While we think of cheno-ams as food sources, Reinhard and colleagues (1985) studies of archaic period coprolites at Dust Devil Cave, southeastern Utah, provide compelling evidence of cheno-am as a medicine for internal parasites. Dust Devil Cave yielded 100 human coprolites distinguished by their considerable cheno-am content and total lack of pinworm (*Enterobius vermicularis*), a human condition that the authors label "near-universal." In some parts of the United States, up until the 1800s, it was grown specifically for this purpose; hence, the common name, "worm seed" (821). Contemporary recipes using the plant confirm its efficacy in treating internal parasites (Moore 1989). Reinhard's (1992:249-250) study of parasitic infestation connect pinworm with anemia and porotic hyperostosis, the resolution of PH in the affected residents of blocks 100 and 1000 could have been due to the use of *Chenopodium*.

Kiva 102: the "*cleome*" *kiva*

"The leaves and flowers are highly esteemed," writes Jesse Walter Fewkes of *tümi hümita*, the Hopi name reported for *Cleome integrifolia* (Fewkes 1896:16). Translated, the word is said to mean, "land corn kernel.” Even in its translation we can deduce something of the importance of *Cleome* to the historic Hopi in its connection with corn. *Cleome integrifolia* var. *angusta* M. E. Jones is a synonym of *Cleome serrulata* Pursh. (Rocky Mountain beeplant)(The Plant List 2013). *Cleome serrulata* is a plant associated with ritual, Hopi prayer sticks or *pahos* (Whiting 1939:44; 78), serving both mundane and sacred functions, its Zuni name, “hands many seeds” is recorded by Stevenson (1915).

Kiva 102 is an aboveground circular kiva Pueblo III style kiva and abuts kiva 107 (the “*religious room*”) to the north. A sample from the central hearth yielded *Cleome* seeds. Malvaceae seeds were encountered above the prepared floor surface. Scott and Aasen (1985:19) report a collection of beans (documented as *Phaseolus vulgaris*) on the floor. Other food remains include maize and cheno-ams found near the hearth deflector. The kiva hearth was unusual, apparently divided using vertical stone slabs suggestive of a dual purpose for the feature. Under a segment of the encircling bench of the kiva (segment 6) a niche contained burned processed maize kernel and cupule fragments, burned cheno-am seeds and embryos, and an uncharred *Cleome* seed. A large quantity of cheno-am pollen, suggestive of the storage of chenopodium greens, was found in another niche nearby. *Cleome*, *Zea mays,* and Cruciferae (Mustard family) pollen was also identified here. Charred and uncharred *Juniperus* (likely *J. osteosperma*) stems fragments and *Pinus* needle fragments are documented. The presence of less common remains such as *Phaseolus*, particularly in quantity in the context of a hearth, tells us that the residents of block 100 enjoyed a varied and presumably adequate diet that included domesticates and leafy greens shortly prior to the final warfare event. The plant record of the tower is consistent with both kiva 107 and 102.

Kiva 102 is exceptional also for a unique 1-metre long niche that takes up the majority of space beneath the northernmost kiva bench segment (CCAC 2004: Kivas, Structure 102). This niche was found empty. The kiva also contained two beautifully crafted tools, a serrated biface (possibly used in the processing of yucca for its fibrous “twine”) and a particularly beautiful polishing/ hammering stone (ethnographically used to polish pottery)(CCAC 2015a:photographs 2972 and 2973). An unusual rectangular Pueblo III White Painted mug, one of only two recorded for SCP (vessel number 22; CCAC 2015a:photograph number 2711) was recovered in the kiva. Kiva 1501 (the east kiva) in the D-shaped building yielded the only other known rectangular mug at SCP (CCAC 2015a:photograph number 3985). Only excavations at Yellow Jacket Pueblo produced rectangular painted mugs (CCAC 2015a:photograph number 4969). The black painted designs on all three are geometric. The apparent rarity of these types of mugs is interesting in the context of block 100 and 1500.

Another unusual artifact, a miniature *tchamahia*, “stone hoe,” was recovered in kiva 102. Also known as “rain knives,” [Hopi] and considered sacred objects on altars (Parsons 1996

[1939]:333). Tchamahia are also the name given to ancient Stone people (211). *Tchamahia* play a role in Cushing's (1920:238-242; see pp.163, 185 and 194-195) reiteration of the *Cactus Picker* dance.

<u>Midden 103: the "*sandhill crane*" *midden*</u>

Located against the outer south wall of kiva 102, this midden contains evidence of consistent food waste discard. The lowermost layers accumulated below the base of kiva 102 and, therefore, represent early discard in the block previous to the construction of the kiva. The plant remains recovered in these layers and overlying ones show a continuity of discard that does not support an interpretation of a change in resource use. There is evidence of a continuity in discard of pharmacologically active plants also. Typical Pueblo III staples are evident and include ground maize remains, cheno-am, *Opuntia*, Poaceae (unknown grass), *Physalis*, and *Portulaca*. A core faunal group of animal bones are represented here that we see accumulating through time and throughout the village consisting of *Meleagris gallopavo* (turkey), *Sylvilagus* (cottontail), *Neotoma* (wood rat) and Sciuridae (squirrel), traditional Pueblo III protein sources (Reinhard 2006). Unusual bird remains suggestive of symbolic potential or spiritual themes (Muir 2007:paras. 58-64) as noted previously were present. The identification of *Grus canadensis* (sandhill crane) when viewed from ethnographic data is suggestive of the "medicine partner" with the Bear in Zuni cosmology suggesting additional evidence of clan-based organization in the block. Sandhill crane remains were found only in this midden (CCAC 2004: Nonstructure 103, Animal Bone Analysis Summary) and in the roof fall of the D-shaped building (Muir 2007:Table 10).

<u>Room 104: the "*Cleome pottery box*" room</u>

Room 104 has been inferred as a workroom based on the quantity of tools such as manos and metates found here (CCAC 2014: Rooms, Structure 104). From my perspective it is the rectangular White Painted pottery box with *Cleome* imagery painted inside that makes this room a standout at SCP. The box is very small, approximately 6-7 cm (width) x 11 cm (length). The size alone suggests a special purpose. In addition to *Cleome* seeds, *Cleome* pollen has been found in west oriented blocks 100, 200 and 500. This was interpreted to represent the use of the plants in activity areas (Gish 1988, 1990; Scott and Aasen 1985). Unfortunately, pollen sampling is limited to these few locales. The *Cleome* box is large enough to hold pollen, seeds, or ground seeds, but in limited quantity. There are two other rectangular boxes, found in a niche in kiva 501 (block 500), neither has interior decoration or obvious plant imagery.

Room 104 also had a firepit. Firepits are typically found in rooms such as tower 1008/1019 (1008 is the lower storey, 1019 is the inferred upper storey) in block 1000. Rooms with firepits are notable in the historic period as residences and special purpose rooms (see Cushing 1920). The contents of the firepit reflect the last use of the feature probably just prior to the attack. The remains included various shrubs: *Artemisia tridentata* (big sagebrush), *Cercocarpus* (mountain mahogany), *Ephedra* (Mormon tea), *Juniperus* (juniper) and *Pinus* (pine). These plants are not a typical combination for late occupation firepit/hearth-type features at SCP although juniper and pine charcoal are ubiquitous in virtually all used thermal features.

Room 105: the "*craftsman's room*"

Room 105 is the inferred workroom of the "craftsman" (HRO 2)(Kuckelman and Martin 2007) whose skeletal remains were found interred (Adams 1985a, 1985b) in this location. The bedrock surface of the floor testifies to the sharpening of tools by its numerous circular and oval grooves (CCAC 2004: Rooms, structure 105). Like so much of the block, room 105 contained unusual plant collections: uncharred *Mentzelia*, *Juniperus* stems (likely *J. osteosperma*), *Pinus* needles and a quantity of cheno-am seeds.

Kiva 108: the "*Kokopelli*" kiva

Kiva 108 is characterized by its four-pilaster roof supports typical of an earlier "ancestral" kiva design. Pueblo III kivas in the Mesa Verde region are known for six-pilasters, four-pilaster construction is characteristic of the Pueblo II period (CCAC 2004). The kiva's other distinguishing feature is the plastered over *Kokopelli* figure on the floor. The extinguishing of the Kokopelli figure would require some time depth in residence. If kiva 108 was constructed in the A.D. 1270s as has been proposed (Kuckelman et al. 2007), then little time passed before the imagery was removed, unless it existed prior to the construction of the building. Combined with evidence of older ideas (the four-pilaster construction), I suggest that earlier dates noted for construction of block 100 are plausible for this kiva. The removal of *Kokopelli*, like the sealing over of ritually important floor features in the D-shaped building late in the occupation, hints at a shift in ideological thinking, occurring as it apparently did there after A.D. 1270-1271. An alternative explanation is that *Kokopelli* signified a group identity. Flutes play a role in war, in connections with Bear clan, west directional associations and War Brothers mythology, characteristics I explore in depth in chapter eleven. Kiva 108 is the traumatic site of the deaths and apparent dismemberment of two individuals found on the floor. These individuals have been described as a probable female, 17-26 years of age, the other, a probable male of approximately 12-15 years of age (Kuckelman and Martin 2007). A short-term campfire was built on top of the collapsed roof of kiva 108, may have served to deliberately burn the roof, although this was only partially accomplished, as much of the roof did not burn.

Midden 109: the "*Kokopelli kiva*" midden

This midden (nonstructure 109) is located on the east side of kiva 108. A flotation sample and faunal remains (Muir 1999, 2007) provide clues to discard of unwanted materials used in the kiva. A flotation sample contained charred cheno-am and Poaceae seeds, and *Juniperus osteosperma* twigs and scale leaves. Charcoal of *Juniperus*, *Pinus* and *Prunus/Rosa* (chokecherry/rose-types) suggest the remains of fuel wood used in the kiva hearth. The content of this midden appears to differ from that of midden 103, which is notable for its abundance and variety of plant (and animal) remains. A few turkey and cottontail bones and a single deer-sized bone were recovered in the midden but the kiva itself contained additional faunal evidence that included *Odocoileus* (deer). The remains of larger animal remains such as deer are interpreted to represent a latest occupation hunting strategy (Muir 1999, 2007). Ethnographically, hunting larger animals is associated with celebrations or special occasions confirming feasting activity for Sand Canyon Pueblo (Driver 2002; Muir 1999, 2007). Underhill (1991[1946]:58) makes the following observation of the pueblos in early 1900s:

> When they had meat, it was a special occasion. Still, there must have been much more game in the early days than there is now, for old accounts speak of deer, antelope, mountain sheep, mountain lion, gray wolf, badger and fox. Pueblo people hunted all of these, for besides the meat they needed skin for clothing and for drums, sinew for bow strings, sewing and all kinds of fastenings, bone for tools and wall hooks, and hooves for rattles...At home they could get small animals, like gophers and ground squirrels, but most of all the rabbit, chief animal food of all Indians in the Southwest. Hunting often meant a long trip away from home and the best way to do it was for a number of men to work together. They would go to some place where they knew the game was to be found, then drive the animals into a canyon or a roughly made corral... (58).

A striking similarity in material culture as seen in the historic period are evidenced in block 100. Other excavated units support this contention.

Architectural block 200 – the "gap" block[56]

URL links noted in the above footnote above provides contextual information for this discussion. Block 200 is distinguished by a number of characteristics including an apparent partial disuse of some rooms, the re-purposing of other rooms for trash, and tool collections that included *tchamahias*,

[56] Topographical map of block 200 is detailed on Map Number 4006 Site 5MT765, Block 200 Topography. Made available courtesy of Crow Canyon Archaeological Center (CCAC 2004). http://www.crowcanyon.org/ResearchReports/ResearchDatabase/maps/qryMapZoom.asp?FileName=e:\editor\maps\5MT765\Map4006.tif&Zoom=30&Site=5MT765&MapNum=4006&RequestPage=&RequestPage=All_Maps_Page&MapType=WSCulturalUnits.The block as excavated is detailed on map 4055, Site 5MT765, Excavated Portion of Architectural Block 200, Plan View available at: http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4055.tif&Zoom=25&Site=5MT765&MapNum=4055&SUNum=208&SUTyp=Structure&SUDesc=abovegrou

manos, metates, mauls, and a rare stone mortar. It appears that the making of tools continued, as did the collection and use of a variety of plants, until the final days of village occupation. The presence of the mortar indicates specialized processing of plants. Room 205 contained a significant quantity and variety of pottery, some of it painted (Till and Ortman [2007] provide a comprehensive review Sand Canyon Pueblo pottery). Unlike block 100, no evidence of plant imagery or similarly unusual plants was identified in this block. No articulated human remains were encountered, although scattered human remains were found.

Located southwest of block 100, block 200 makes use the site-enclosing wall to form the outer walls of four of its rooms. A circular tower offset from the site-enclosing wall and remodeled into a kiva, seven rooms, two extramural surfaces and portions of two middens were excavated (Kuckelman 2007b)**.** This block could be characterized, as block 100 has been, based on the abundance and variety of tools found here, suggestive of talented toolmakers and craftspeople. However, block 200 is dissimilar to other excavated blocks based on, what I characterize as, many "gaps." There are gaps in the site-enclosing wall here, gaps in the temporal record, and gaps in our understanding the development of the block and in our knowledge of certain artifact classes. Taken together, however, some interesting information can be gleaned about the people who lived here; people whose material remains vary from those of the residents of block 100. Beginning in the kiva, I provide a synthesis of the block, focusing on those rooms and deposits that provide information about the plant remains.

Kiva 208: the "*tower/kiva*"

Many bone awls and stone axe heads were encountered during excavation in the roof fall of this renovated tower. A "well-crafted mortar and pestle," is rare in the region and found in this kiva (another was found in structure 512, in block 500)(CCAC 2004). An ethnographic interpretation suggests that stone mortars were used in the processing of particular plants. Hough (1897:40) makes note of the use of stone mortars for the processing of *Sisymbrium canescens* Nutt. (or, *Sisymbrium pinnata* [Walter] Britton, western tansymustard) seeds to make an "oily liquid, which serves as a medium for the iron paint used in pottery decoration." Stone mortars also likely played a role in the crushing of "sandhill-crane all beans medicine" and served to ensure a good bean crop (Stevenson 1915:85).[57] The pottery assemblage here includes some beautifully decorated Mesa Verde Black-on-

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nd+kiva&StartingSUTypePage=Structure_Page&Crit=Kivas&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Structure_Page&RequestPage=MapList_Page

[57] Seeds of native mustards (Brassicaceae) are often similar in morphology and very small. Stevenson (1915:84) records the use of the small mustard seed, *Haʼkoʻlokta noʻwe aʻwa aʼkwawe*, as "sandhill-crane beans all

white bowls and a densely decorated ladle that suggests a design of leaves. Excavator notes suggest that some associated rooms and surfaces were cleared of possessions without obvious evidence of struggle (CCAC 2004). An alternative explanation is that the raid resulted in the removal of food and other materials and/or that some of the residential group had moved prior to the final attack.

Kiva 208 has none of the kiva corner rooms that typify Pueblo III kivas although the room block may have served in this capacity. Midden 209 (Nonstructure 209) located near the outer southeast wall of the kiva was likely the refuse dump for the building. At some point in the occupation, the use of room 204 transitioned from its original unknown purpose to that of space for trash suggesting that priorities shifted here, a similar shift is noted in blocks 1000 and 1200. Archaeobotanical remains included *Artemisia tridentata, Cercocarpus, Juniperus* and *Pinus* charcoals, *Juniperus osteosperma* (twig), and seeds of cheno-am, *Helianthus* (sunflower), *Phaseolus vulgaris*, *Physalis longifolia* (common groundcherry) and *Zea mays* (kernels and cupules). In the roof fall of the collapsed kiva roof were maize cobs and juniper charcoal. A burned spot designated as a postabandonment feature yielded the same. The faunal record of the kiva includes turkey, deer-sized bones, cottontail and woodrat bones. The hearth contained large bird bones (for a complete listing see CCAC 2004: Kivas, Structure 208, Animal Bone Analysis Summary). With the exception of the larger animals, these remains suggest a typical Pueblo III diet. Artifacts included a chipped stone tool of inferred archaic style (a turtle backed scrapper), two slab metates, manos, some with little or no use-wear, and a few beads made of bird bone. Two flotation samples were evaluated for the partially excavated midden on the outer southeast wall of the kiva, which yielded little in the way of plant food remains although the faunal record was varied. High relative counts of turkey (and unidentified large birds that could be turkey), deer and cottontail rabbit, with very low relative counts of small mammal bones but much species variety (pocket gophers, squirrels, voles, rodent types)(CCAC 2004). An unusual bone from a *Buteo* sp. (hawk) was encountered here probably not used for food but in the course of spiritual activity (Muir 2007). If consumed as a strategy for mitigating food shortages, I would expect to see further unusual remains in the kiva hearth and discarded on benches, which we do not. The midden is also distinguished by a *tchamahia.* Leaving the kiva and moving clockwise through the block as excavated reveals information of the residency here.

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medicine" for *Thelypodium wrightii* A. Gray (Wright's thelypody). A synonym for *Stanleyella Wrightii* (A. Gray) Rydb., Stevenson (1915:85) records their use by Zuni women: "The seeds are removed from the pods and crushed by women of the Sandhill Crane clan, and mixed with beans that are to be planted. This procedure is said to cause the bean crop to be as abundant as the seeds from the pods. This medicine belonging to the Sandhill Crane clan." The *Powamuy* ceremony owned by the Badger clan and its "kiva crop" as noted by Whiting (1939) are intriguing in this regard.

Room 206: "*corner bin*" room

Situated on the southwestern side of the kiva was a room that had been subdivided and likely served as an open courtyard area at one time originally a much larger room that probably served as an open courtyard area between the *tower/kiva* and the site-enclosing wall. Three rooms occupy this gap, 204, 205 and 206 (see map link). Room 206 is clearly a renovation subdivided from what was once a larger room suggesting some time depth here. It was constructed after tower/kiva remodeling and originally had a doorway leading onto an unexcavated space to the south that was later partially blocked by the construction of the corner bin, a storage feature. The doorway was remodeled into a pass-thru that perhaps served a kiva suite to the south. The room had a niche. Samples from the bin yielded uncharred cheno-am seeds, an unidentified charred seed, *Zea mays* remains, *Artemisia tridentata* and *Juniperus* charcoal. Vegetal samples collected from roof fall were found to contain *Zea mays* remains, *Pinus* and *Ephedra* charcoal. The *corner bin* room is notable for its absence of maize remains, possibly the result of pre-harvest or the raid, the bin presumably serving as a storage area for cobs or kernels. Few artifacts are recorded for the room and include pottery, a deer-sized bone scraper and three two-hand manos. Undescribed pigment was noted for the surface of the mano.

Room 204: "*renovated kiva access*" room

Interpreted to be a storage room with a niche (CCAC 2004), room 204 transitioned from a space accessed through a roof hatchway to one with a doorway allowing mutual access with the tower/kiva. Few artifacts were located on the floor to suggest its "new" use. Investigators noted no disturbance in the fill and inferred that room 204 was a storage room that had fallen into disuse. A roof fall layer within the fill contained a variety of plant remains. Charcoal was identified as *Amelanchier/Peraphyllum* (serviceberry/peraphyllum), *Artemisia*, *Juniperus*, *Quercus* (oak), *Pinus* and *Purshia* (bitterbrush/cliffrose-type), not typical fuel wood sources. A single *Juniperus* osteosperma twig was noted and a number of small seeds: cheno-am, *Physalis longifolia*, and *Portulaca retusa* (purslane). Some maize cupules were recovered. Vegetal samples consisted of cob remains and juniper charcoal. No faunal evidence was identified within the room although a deer bone was found in the doorway. A few chipped stones and sherds were the only artifacts located here.

Room 203: "*tchamahia*" room

Located immediately to the north of room 204 is an inferred "storage" room that contained many stone tools such as axes, manos, three slab metates, and artifacts such as a remnants of a sandal. A *tchamahia* made of siltstone (Morrison chert) was also found here (CCAC 2004: Rooms, structure 203). A small niche was built into the northeast wall hinting at a focused use of the room. Plant evidence in the wall and roof fall, likely originating from a roof activity area, contained a relative abundance of Zea mays kernels (28 specimens), *Phaseolus vulgaris* (three specimens), and *Juniperus* charcoal. Clearly people were using domesticates in the context of the roof as one of the latest activities that occurred in this block.

Room 202: "*green pigment*" room

Room 202 was one of three rooms at Sand Canyon Pueblo where green pigment was found (the others, two bi-wall rooms in the D-shaped building). This is the site of the second breach in the wall and it is in this location that the wall is the thickest and "most massive" (CCAC 2004, Rooms, Structure 202). The use of the room transitioned twice: it was originally a large room or outside courtyard, then constructed as a large room and later subdivided to create room 207 to the northeast. It has a niche but no artifacts or faunal remains are recorded. Charcoal from a vegetal sample from a deposit of wall fall is identified as *Juniperus*, *Lycium* (wolfberry), and *Pinus*. Juniper and pine are ubiquitous fuel sources at SCP but *Lycium* charcoal is rarely identified. An additional specimen was recovered from a kiva hearth sample in block 1000 (kiva 1012), room 1209 in block 1200 and one found below a cultural surface in construction refuse fill at the entry to kiva 1502 (the smaller, later west kiva). Of all the samples documented by CCAC over multiple excavations of other sites, only two other flotation samples produced evidence of *Lycium*. Both were collected from a primary refuse deposit on an extramural surface at Yellow Jacket Pueblo (CCAC 2015a). Nineteen charcoal specimens from that site were tentatively identified as *Lycium*. This is an important archaeobotanical species because of its cultural associations.

Room 202 also provides the most abundant evidence of plant use for block 200, presumably serving as a location for the *tower/kiva* trash later in the occupation. Flotation sample data include charcoal from *Juniperus* and *Pinus*, *Amelanchier/Peraphyllum*, *Artemisia tridentata*, *Purshia* and *Quercus* likely *Quercus gambelii* (Gambel's Oak)(CCAC 2015a) that dominates the canyon today. These are similar findings to that of elsewhere in this block. Typical fuel choices at Sand Canyon Pueblo are juniper, pine and rose-species. Sagebrush and oak have ethnobotanical uses most associated with ceremony (see Moerman 1998).

Besides its many gaps, block 200 shows evidence of connections with its northwest neighbours in block 100. The plant remains are similar and include beans, maize, wild seeds and large game animals in a temporal context associated with the events of ca. A.D. 1277. The presence of another *tchamahia* whose ethnographic import is significant to ceremony and war, is suggestive of ceremony. Similar to block 100, block 200 material remains are consistent with a fall hunt and a residency where some people moved away prior to the final attack and others remained. Maize and beans are present in final occupation contexts. An unusual plant, *Lycium*, has ethnographic associations that suggest that it is an unlikely choice of fuel material.

Lycium pallidum: potent ethnomedicine and warrior preparations

Lycium pallidum Miers (pale wolfberry) was a drug and a ceremonial medicine (Fewkes 1896:19). The berries were processed in numerous and a varied food preparation in historic times but the pharmacology of Lycium suggests additional reasons for its use. *Lycium* berries (and sometimes the roots) are considered to be one of the most important drugs in Chinese ethnomedicine. Phytochemical research has demonstrated the effectiveness of the plant for its antioxidant, hypoglycemic, hypotensive, and immune stimulating effects. More recent studies indicate anti-cancer activity, beneficial neurological effects, anti-fatigue, and endurance benefits (Luo et al. 2004: 10058; Mocan et al. 2014; van Wyk and Wink 2004:195). I am unaware of any testing of native *Lycium* species for pharmacological potential but I suspect that the visibility of the plant and its potential health benefits indicate that ancient Puebloans were knowledgeable of its effects. The Zuni are noted to give the ground leaves, flowers and twigs of *Lycium* to warriors to chew and rub on themselves for protection in battle (Moerman 1998:323). The relationship of *Lycium* with ceremonial or war preparations hints at knowledge of anti-fatigue/endurance benefits. It is possible that the pale colour green of the plant held important associations for the assessment of the plant as having particular qualities also and the absence of descriptive detail in ethnobotanical and ethnographic sources could be the result of specialized knowledge. *Lycium* is documented from Hopi First Mesa accounts as playing a role in the Hopi *Niman* ("*Nima'n*") or "home-going" ceremony held every July to mark the end of Katsina visitation for the ceremonial year (Fewkes 1896:19; Parsons 1996 [1939]:509-510). Features of this ceremony include eagles and hawks playing roles in the closing rituals of the ceremony. Hawk (*Buteo* sp.) remains were located in the midden (midden 209)(in addition to *Lycium*, the refuse under the courtyard surface outside of the west kiva [plaza 1500] produced evidence of hawk remains). The presence of the green or blue-green pigment in room 202 also has interesting metaphoric connections to the D-shaped building where two rooms were found to contain green pigment, the colour has cultural significance to Puebloan people in historic times (Ford 1980; see Table B.1, Appendix B). Whiting (1939:44-45) records that the colours blue or green are associated with the southwest direction in Hopi cosmology.[58] The apparent lack of *Lycium* remains at SCP generally also suggests that its primary use was not as a fuel source, its berries not as a typical food. Themes of war are

[58] An association is made between supernatural beings that occur in male and female pairs with the colour blue and green, sometimes referred to as blue, other times considered green (Parsons 1996 [1939]:102).

consistent within other plants found at SCP. The between *Opuntia* (prickly pear) cactus and *tchamahia* provide additional data from which to assess Sand Canyon Pueblo priorities.

Tchamahia: Opuntia, war, and cosmological connections with the D-shaped building

Like kiva 102, block 200 contained *tchamahia.* Cushing's (1920:238-242, and chapter six, pp. 158-159) description of the man who, "emblematic of his office," carries "a little wooden hoe of the ancient style" and features in the dance with the Ancient Moon-Woman Cactus-picker, provides an interpretation for the stone hoes and block 200. LeBlanc (1999:115) notes that the softness of the stone used in their manufacture would preclude them as effective weapons and digging implements. Linked to ritual contexts associated with war (Cushing 1920; LeBlanc 1999:116; Parsons 1996 [1939]), soft stone implements or weaponry would be highly desirable in re-enactments of war in ceremony. "*Chamahia*" and "Stone Hoe people" are featured in Emergence narratives:

> The world above, before or for a time after the Emergence [of the people from the underworld] may be described as soft, damp, fluescent, to be hardened later into rock, in which are sometimes preserved tracks of the early beings. And it was at this time that some of the Spirits became stone, among others Lightning Man who was traveling south with the Laguna people from White House or those dim Stone people called Chamahia who lie on altars or are invoked in rituals (Parsons 1996 [1939]:Table 2).

Parson's (1996 [1939]:211, Table 2) describes "*chamahias*" as "rain knives" of ritual in the ancient pueblos. The metaphoric significance of soft and hard is mirrored in the existential realm of Puebloan cosmology; the hardening of soft stone into rock captures the mythic nature of the underworld. Here, the world that existed "above, before or for a time after Emergence," is described as "being soft" to be "hardened later," much like the characterization of the people, who emerged in "soft," but were hardened through experience later, becoming "Pueblo" (211).

> In the ruins of the San Juan drainage and nowhere else, except at Awatobi [Hopi village], have been found blades of yellow hornstone or black slate that were used as hoes. Such *chamahia* are placed on the Powamuy altar (Orayvi) and on Antelope altars (Walpi, Second Mesa), and I notice one figured on a Zuni Rain chief's altar. The stones in the Mishongnovi [another Hopi village] and Oraibi Antelope society's ...fetishes appear to be *chamahia*. The base of the Mosongnovi fetish is wrapped with coils of buckskin strips stained red. Within the projecting eagle-tail feathers of which red-stained, downy feathers are attached, is concealed a "handsome and finely polished jasper celt, yellow in color, and about ten inches in length." To Hopi *chamahia* represents "rain knives" dropped from above by the Chiefs of Directions; and the term is also applied to ancient Stone people, but whether to the stone when it was alive or to users of the implement is not always clear (Parsons 1996 [1939]:211).

Tchamahias were found in four architectural blocks, 100, 200, 500, 1200, in the context of a kiva, one a midden, and three rooms. The ethnographic record indicates that these artifacts served an ideological role. The apparent absence of *Opuntia* evidence is curious in this block, compared with block 100 and ethnographic connections between cactus, ceremony, *tchamahias* and ancient stone people and stone hoes. Although not extensively sampled for flotation, the absence of *Opuntia* seeds in a kiva suite that to all intents and purposes was occupied until the raid, provides some evidence for the use of *Opuntia* as a medicinal treatment in block 100, where it was clearly needed. The theme of "mock violence" in ceremony is recorded ethnographically as occurring particularly during the winter solstice in the contemporary pueblos situating cactus seeds and fall season hunts and raids well for SCP. The ceremonial "battle" is not considered play-acting, however (Ortiz 1972:151). The *tchamahia*, a "soft" vs. hard weapon makes sense in this context. *Tchamahia* in this latest occupational time period could represent evidence of preparatory fall ceremony, for impending warfare, or, as ceremonially significant for the mitigation of warfare if this is the case.

Architectural block 400 – test pit excavation

Kiva 400 was a test trench excavation. I examined a bulk volume sample from the hearth. The URL noted in the footnote (57) provides detail of the extent of excavation. Located on the southwest canyon rim adjacent to the drainage, the kiva is of an unknown type. An unintentional discovery of an older woman was encountered overlaying the central hearth, a context indicating she died as a result of the attack. The roof of the kiva was intentionally burned at some point afterwards and hearth samples could contain evidence of last day's activity (CCAC 2004: Kivas, Structure 400).[59]

Architectural block 500 – the "subterranean kiva" block[60]

I characterize block 500 based on its subterranean structures. Like block 100 and 200, block 500 demonstrates another architectural configuration for Sand Canyon Pueblo. Subterranean kivas, like

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[59] The extent of excavation defined as block 400 are outlined in Map Number 4008, Site 5MT765, Block 400 Topography, courtesy of Crow Canyon Archaeological Center (CCAC 2004). Available at: http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4008.tif&Zoom=25&Site=5MT765&MapNum=4008&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=.

[60] Map 4009, Site 5MT765, Block 500 Topography outlines the extent of excavation, courtesy of Crow Canyon Archaeological Center (CCAC 2004). http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4009.tif&Zoom=25&Site=5MT765&MapNum=4009&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=. The excavated portion of the block is detailed in plan view on map 4087, Site 5MT765, Excavated Portion of Architectural Block 500 made available courtesy of Crow Canyon Archaeological Center (CCAC 2004).http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT7

the Pueblo II style *Kokopelli kiva* (108) are ancestral building styles. Block 500 is the oldest known occupied area of Sand Canyon Pueblo and people were living there at the time of the raid. Like the previous blocks, block 500 also contained intriguing features and artifacts. The URL link provided in the footnote on the following page provides a plan view of the architecture that helps to situate the data presented here.

Located south of block 200 and west of the drainage, block 500 is separated from the site-enclosing wall by several kivas and small rooms and borders the main plaza. Two kivas, ten rooms, a courtyard surface and portions of two middens were excavated (Kuckelman et al. 2007). Block 500 is important for its potential to shed light on the earliest plant record of SCP. Beginning in A.D. 1200, tree-ring cutting dates capture decades through to the A.D. 1250s and none after A.D. 1252 (Kuckelman, ed. 2007:stem-and-leaf plots). The block is most obviously distinguished by its subterranean kiva (501) and separate but seemingly associated subterranean room (514). Surrounded by a courtyard, room 514 is located in the southwest corner of the suite. Similar to room 203 in block 200, a *tchamahia* made of "fragile slate-like material with polished edges" was recovered in the kiva (CCAC 2004, Kiva, Structure 501, Other Artifact Analysis Summary). Block 500 is also notable by the presence of a stone mortar similar to the mortar (and pestle) found in kiva 208. A female of approximately 45-50 years old with evidence of arthritis and slight to moderate degenerative joint disease was found in the roof fall of the kiva. A possible female (15-20 years of age) appeared to be formally buried with undescribed grave goods in the wall fall associated with the southwest area of the courtyard (CCAC 2004; Kuckelman and Martin 2007). The block contained many useable tools and whole vessels—some of the pottery vessels are particularly beautiful—and it is likely that the residents here fled without returning to remove their possessions. In this next section I highlight areas of interest for interpretation of the occupancy and the plant record.

Kiva 501: the "*subterranean tchamahia*" *kiva*

The kiva has several niches, one located below the encircling bench that contained two rectangular pottery vessels ("boxes") complete with lids and decorated exterior geometric design (CCAC 2004: Kivas, Structure 501; CCAC 2004: photo 7809). Unlike the White Painted "*Cleome*" box in size and decoration, these are larger. An architectural pictograph consisting of four layers of multicoloured wall murals depicted bands, stripes, dots, and triangles painted with white, gray, green, gray green and red pigments is located on the northwest wall of the kiva under two benches. Colours are

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symbolically rich and have connections with culturally important plants (Ford 1985; Whiting 1939; see Table B.1, Appendix B).[61] Flotation samples from the kiva hearth and a small pit (feature 23) located near the bench niche, contained seven pieces of modified stone/mineral but little in the way of plant remains. A kiva hearth sample contained *Juniperus* charcoal and several *Zea mays* cupules. A flotation sample collected from the small pit contained *Amelanchier/Peraphyllum* and *Juniperus* charcoal and a single cheno-am seed. Faunal remains recovered in the fill of various benches consisting of a scant collection of turkey and cottontail bones. The artifact assemblage included an antler tool, two drills, two two-hand manos and at least three awls. A few polishing stones were noted, one found in another pit dug into the floor surface (feature 28). The most intriguing artifact in the kiva is the *tchamahia*.

Like block 100, pollen samples collected from the floor of kiva 501 indicate maize, beeweed [*Cleome*], parsley/carrot family (Umbelliferae), Cheno-am and maize pollen was present; the patterning of pollen indicates separate processing areas for “beeweed, carrot [parsley] family and minimally maize” (Gish 1990:14).[62] *Cleome* cannot be ruled out in other architectural blocks at SCP in the absence of seeds or other “hard” remains, pollen samples were not collected or examined elsewhere. Similar to the *tower/kiva* (208), another rare mortar was found in block 500 (room 512). How mortars and *Cleome* intersect at Sand Canyon Pueblo is unclear. The use of mortars to make a black paint using *Cleome* and tansy mustard (the “sandhill crane all-beans medicine” of the medicine partner of the Bear clan [Stevenson 1915:85]) is documented in several sources (Hough 1897:40; Stevenson 1915, Whiting 1939) clearly ties cultural significance to these findings.

<u>Courtyard 513: *pre-A.D. 1252 refuse*</u>

The earliest use of block 500 is found in the midden below the courtyard that surrounds the kiva. Deposited between the kiva and room 506 (use unknown) to the northwest, this refuse is estimated as pre-A.D. 1252. The clearest evidence of the earliest plants and, thus, a baseline for comparison with later deposits, only a single flotation sample has been assessed. *Juniperus*, *Pinus* and *Prunus/Rosa* charcoal were identified in this subsampled volume. Numerous *Zea mays* kernels and cupules and a specimen of *Stipa/Oryzopsis hymenoides* (Indian ricegrass) were identified. After the courtyard was

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[61] Whiting (1939:45) reports the colour white represents the northeast direction, gray the nadir, green the southwest, red the southeast, yellow represents the northwest.

[62] Gish (1990) found *Cleome* pollen at other Sand Canyon Locality sites: the Duckfoot site, Green Lizard site, Roy’s Ruin, Lillian’s Site and Troy’s Tower. Additional *Cleome* information is provided in chapter ten. Other cultural pollen identified for kiva 501 is “cholla, mustard, mint, legume, purslane and potato family (Solanaceae)”(21). *Cleome* pollen is also present in the tower/kiva 208 with its mortar and pestle (21) indicating the use of *Cleome* leaves or roots in three blocks at SCP.

built, it served as a working area. Many ground and pecked marks and grooves in the bedrock suggest that tool sharpening was one of the activities that occurred here (CCAC 2004: Middens, Nonstructure 513). Kiva 501 and the courtyard are bordered on the northwest by a block of seven rooms. Four rooms shared mutual access with the courtyard.

Room 503: *room block mealing room*[63]

Block 500 is notable for its separate working mealing room that contained four metate bins. No refuse was found and the room retained its function until the end of the occupation. This is in contrast to other areas of the village where mealing rooms were repurposed and in the great kiva, the bins dismantled and metates moved elsewhere. The room also has an early history. A firepit was encountered under one of the bins. A flotation sample from this feature produced *Juniperus* charcoal, the remains of *Zea mays* (likely ground based on a relative abundance of cupules [50 specimens]), cheno-am, *Opuntia*, and *Physalis longifolia* seeds. A charred cottontail rabbit bone was recovered in the firepit fill (CCAC 2004: Rooms, Structure 503, Animal Bone Analysis Summary). These remains reflect the typical Pueblo III staples (Minnis 1989; Reinhard 2006). As an early/earliest occupation feature, there is little difference between its remains and that of block 100's tower firepit and *Cleome kiva* hearth. A few charcoal pieces of *Juniperus*, *Prunus/Rosa*, and an unknown wood and a relative abundance of *Zea mays* cupules were identified from surface samples. Three *Juniperus* twigs and leaves were found in one of the metate bins. The room contained artifacts, including a scraper made of a deer-sized bone, found resting in one of the metate bins, and numerous pottery sherds and complete vessels were located both on the floor and in the roof fall (CCAC 2004: Rooms, Structure 503, Animal Bone Analysis Summary). The residents of the block clearly had little time to remove their (likely prized) possessions when they left.

Room 505: *firepit room*

Room 505 had three separate surfaces with a firepit located on the latest. Both this room and room 506 to the west appear to be the result of a renovation that divided a much larger room. Two two-

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[63] Map 4101 Site 5MT765, Room 503, Surface 1 shows a plan view of the mealing room (structure 503) and its four metate bins, made available courtesy of Crow Canyon Archaeological Center (CCAC 2004). http://www.crowcanyon.org/researchreports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4101.tif&Zoom=25&Site=5MT765&MapNum=4101&SUNum=503&SUTyp=&SUDesc=&StartingSUTypePage=Structure_Page&Crit=Rooms&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Structure_Page, a photo also made available shows the assemblage in a photograph taken in 1987 (Photo 7778 Plan view, final excavation photo, courtesy of Crow Canyon Archaeological Center (CCAC 2004): http://www.crowcanyon.org/ResearchReports/dbw/dbw_ImageZoom.asp?RecNum=7778&Zoom=10&Site=5MT765&SUNum=503&SUTyp=Structure&SUDesc=masonry+surface+structure&StartingSUTypePage=Structure_Page&Crit=Rooms&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Structure_Page&RequestPage=Photosu_no_hro_Page.

hand manos and two slab metates were located on the floor, one suggesting either a workspace or another, less formalized mealing area. The two previous capped surfaces suggest a long history of use. A firepit was located in the northeast corner. A flotation sample from this feature yielded *Juniperus* and *Pinus* charcoal remains, maize cob evidence (a single cupule) and cheno-am and *Physalis longifolia* seeds. Faunal remains associated with surface two included a few bones of turkey, birds larger than mallard and cottontail rabbit (CCAC 2004: Rooms, Structure 505). The last use of the firepit confirms that food was prepared in the room not inconsistent with similar findings elsewhere.

<u>Room 512: *mortar room*</u>

Although no flotation samples were evaluated here, room 512 is an important room for its ground stone artifacts. The construction sequence demonstrates that room 512 was an add-on. A stone mortar, a two-hand mano and a metate were located here. Designated as a storage room, the stone mortar in this location indicates the processing of wild seeds or roots, plants that would not be ground on metates. Under the floor of the room was a midden (nonstructure 518), which may originally have served as a refuse location for the unexcavated kiva to the east or part of an original courtyard area. It contained pottery and sherds, bone tools such as awls. Typical Pueblo III protein staples (turkey, cottontail, jackrabbit or hare [*Lepus* sp.], woodrat and squirrel found routinely in later deposits are here also.

<u>Midden 515: *broken ladle midden*</u>

Located outside the courtyard walls near subterranean room 514, this midden may have served as a refuse area for kiva 501. I categorize this midden for convenience only as distinguished by a decorated Pueblo III White Painted ladle (vessel number 102; CCAC 2015a:photograph number 4297). Refuse consists of debris and numerous artifacts (CCAC 2004: Middens, Nonstructure 515). Vegetal samples consist of maize cob remains (cob fragments, segments and cupules) and charcoal from *Juniperus* and *Artemisia tridentata.* A flotation sample (re-evaluated in chapter eight) contained *Juniperus*, *Pinus* and *Prunus/Rosa*-type charcoals and a small quantity of maize cupules. Faunal remains of turkey, cottontail and small mammals, stone tools and two projectile points are recorded.

<u>Kiva 517: *test trench kiva*</u>

Kiva 517 may not be associated with block 500 due to its context outside the walls of the kiva suite. Evidence of roof dismantling and the dismantling of the hearth deflector suggest that the kiva had fallen into disuse prior to the final attack (CCAC 2004: Kivas, Structure 517). Vegetal samples from the hearth consist of *Juniperus*, *Populus/Salix*, and *Prunus/Rosa*-type charcoals. A flotation sample yielded *Juniperus, Pinus* and *Amelanchier/Peraphyllum* charcoal. A *Cucurbita*-type (gourd/squash), *Opuntia,* and *Physalis longifolia* seeds were also identified. A single Lagomorpha (rabbit/hare-types) bone was identified in the latest episode of hearth use. Typical fuel wood choices (juniper, pine and rose species) and food sources, squash, cactus and groundcherry do not differ from later occupation plant remains. Cottonwood and willow are not a typical fuel wood choices at SCP. Basketry, prayer-sticks and other objects are typical historic uses of these species.

Architectural block 600 – test trench kivas

Block 600 straddles the southwest canyon rim southwest of the spring.[64] Three kivas were partially excavated in this block. Too little was exposed in the test trenches to demonstrate a firm context of abandonment for the entire area. However these excavations are significant for an early tree-ring cutting date of A.D. 1241 and A.D. 1248 for kiva 602 (structure 602) and a latest tree-ring cutting date of A.D 1266 for kiva 600 (CCAC 2004 Kivas, Structure 600; Kuckelman et al. 2007:Table 2), indicating that these structures were not new to SCP. Due to evidence of a violent death in kiva 602, I interpret some samples as representing plant use just prior to the catastrophic events that led to abandonment of the village. The URL link below shows the limited nature of the excavations.

Architectural block 800 – the great kiva block

Located near the canyon rim on the western arm of the village, the block is defined by the partial excavation of the great kiva (structure 800), [65] two ordinary-sized kivas, nine rooms, a single extramural surface and a midden (Kuckelman et al. 2007). Areas of particular interest include the great kiva, four of its peripheral rooms and a midden. For at least some of the great kiva peripheral rooms, disuse occurred while occupation of the village continued (Kuckelman et al. 2007: paras.107-108). The great kiva, itself transitioned into what appears to be a disordered domestic space.

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[64] Excavated sections of block 600 are detailed in Map Number 4010, Site 5MT765, Block 600 Topography made available courtesy of Crow Canyon Archaeological Center (CCAC 2004) at: http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4010.tif&Zoom=25&Site=5MT765&MapNum=4010&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=.

[65] Map 4012 Site 5MT765, Block 800 Topography shows a plan view of the excavated portions of the great kiva block made available courtesy of Crow Canyon Archaeological Center (CCAC 2004) at: http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4012.tif&Zoom=25&Site=5MT765&MapNum=4012&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=

The great kiva

The great kiva (kiva 800), the largest structure at Sand Canyon Pueblo, likely “served an integrative function” for the people of Sand Canyon Pueblo (CCAC 2004: Kivas, Kiva 800). Built above ground, it was surrounded by rooms for most of its periphery. It had no roof, although large roof supports (pilasters) were in place. Presumably a roof was planned and never executed or, the roof was dismantled. A weathered bench under accumulated debris testifies to an open space for some time. A set of two stacked niches in the massive western wall above the encircling bench surface was carefully constructed, the base stone of the upper niche was covered with four or five layers of plaster (CCAC 2004: Kivas, Kiva 800). No evidence of a hearth was located in the areas excavated, although a floor vault and platform in the southeast portion of the kiva was uncovered testifying to an elaborated space. A major transition is evident in the use of the great kiva with the introduction of an informal firepit in the southeast portion of the kiva and refuse dumped in various haphazard ways suggesting that the great kiva was ideologically de-emphasized.

The general architectural characteristics of the great kiva are reminiscent of deep links with the kiva architecture and symbolism of Pueblo Bonito and also reflective of earlier Basketmaker III where evidence of the first community-sized kivas appeared. Kuckelman et al. (2007: Table 3) estimates a pre-A.D. 1257 construction date based on tree-ring cutting data and construction tie-ins with a kiva (kiva 808) located immediately to the west. Immediately to the west-northwest of kiva 808 was a mealing room. This room (814) was partially dismantled for the construction of kiva 808 and postdates at least one of the great kiva peripheral rooms (805). The presence of metates in peripheral room 806 could indicate that this room served as the new mealing room. Another peripheral room, 810, likely also pre-dates kiva 808 and it is safe to assume that the great kiva and some of its peripheral rooms were constructed early in the occupation. Estimated dates for many of the other peripheral rooms range from A.D. 1267-1273 when, according to my scheme, the ideological landscape expanded with the addition of these rooms and the construction of the D-shaped building. At least nine encircling peripheral rooms were added to finished outside wall faces of the great kiva, confirming that the original plan did not include these rooms (Kuckelman et al. 2007: para.98). By the time of abandonment, both rooms 805 and 810 appeared to have been used for a brief time for domestic purposes. An ephemeral fire in the fill of room 805 suggests that attackers either remained or others came later. Articulated human remains were found in the great kiva and kiva 815, as well as scattered human remains in some of the peripheral rooms.

Typical SCP fuel wood sources of *Juniperus, Pinus* and *Prunus/Rosa* charcoal were recovered in the great kiva along with *Zea mays* cob remains, cheno-am, *Physalis longifolia,* and *Portulaca retusa* seeds. In a refuse accumulation near one of the kiva benches *Ephedra, Acer* (maple-type) and *Populus/Salix* charcoals were recovered. *Ephedra* and cottonwood/willow probably represent other uses. *Acer* species are documented as sources for bow making and prayer-sticks (Moerman 1998:39).

Room 805: the "*Cycloloma atriplicifolium*" room

Room 805 is distinguished by a destruction event and unusual plant remains. At least 1.5 metres of the western inner wall face extending to the full height of the room was destroyed or removed. Approximately 25 cm of fill accumulated on the floor after this event. At some point a fire was built or firepit contents were discarded appearing as a burned spot in the fill. The destruction of the wall shares some consistency with the remodeling events noted in other areas of the pueblo, such as kiva 108 and the extinguishing of the *Kokopelli* image, the repurposing of the mealing room in block 1200 and the changing use of the D-shaped building where imposing and clearly important structures were plastered over. I have associated these with a major transition in behaviour and situated these kinds of events in the A.D. 1270s, estimated as at least four years after the D-shaped building was finished and refurbished (perhaps an annual replastering of walls and floors). The destruction of the wall is highly suggestive of the removal of decoration. The act demonstrates a concerted effort to obliterate whatever imagery was present. As with all areas of the village, consideration of the unexpected lends itself to alternative explanations. The plant evidence, as in block 100, is unusual.

Two species, *Cycloloma atriplicifolium* and *Scirpus* seeds have been interpreted as rare and non-local resources, ones that could represent an increase in wild plant procurement outside the area (Adams et al. 2007; Kuckelman 2007b). At least one resource, *Cycloloma atriplicifolium*-type seeds (winged pigweed) are unusual not just for Sand Canyon Pueblo but for all excavated sites in the Sand Canyon Locality. These seeds are rarely identified, too, at Salmon Ruins, the Chacoan style great house located over the border in New Mexico (Adams 2008). The effects of subsampling may be the cause; the cultural use of the plant another. Although not obvious on the landscape today, Heil and O'Kane's (2005) recent survey recorded *Cycloloma atriplicifolium* in Arizona, New Mexico and Utah. Winged pigweed is native to Colorado and the lower 48 states (USDA NRCS 2015). The burned spot produced a rare (although "less" rare) *Scirpus* achene. These taxa were part of a suite of plants recovered from the feature that included *Zea mays* (kernel), *Physalis longifolia*, and *Portulaca retusa* seeds. The only evidence of fuel type is identified as *Peraphyllum* (peraphyllum). Vegetal samples, consisting of *Zea mays* (cob), *Juniperus* and Rosaceae-type (Rose family) charcoal were collected from the fill of the room. No faunal remains are noted for the feature or the room. Above all, *Cycloloma atriplicifolium* (and *Cleome*) are the outstanding "rare" outliers for SCP. How this species fits into the picture of the last days of the great kiva requires an analysis "last days."

Cycloloma atriplicifolium and cosmological associations with war

The use of the great kiva for mundane purposes such as firepits, burned spot, and trash could signify a decreased population, one that could not maintain ceremonial activities, or maintain the elaboration of such activities normally associated with such a clearly important building. Smaller scale ritual use equally plausible. Rooms fell into disuse and kivas left empty in the "transitional" period to provide living space rather than set up camp in such an open building. Ephemeral fires in "postabandonment" contexts could be the result of attackers staying on or returning, keeping in mind that the designation "postabandonment" also reflects the re-use of a space after its original use was discontinued, not necessarily tied to the final attack. Twenty-five centimetres of accumulated sediment over a destroyed and likely decorated wall indicates that room 805 was out of commission for some time.

Richard Ford's (1988:216) caution that "rare little things are often significant for cultural interpretation" certainly applies to Sand Canyon Pueblo. The remains of *Cycloloma atriplicifolium* seeds recovered in peripheral room 805 suggest alternative explanations. The seeds were likely harvested in the fall (Bohrer 1978:14); represent stores or, alternatively the use of the leaves or roots. Although the *Cycloloma* evidence is not obviously related to the destruction event, the destruction event could be related to the transition of the original purpose of the great kiva that undoubtedly provide clues to the events that led to the final depopulation of the village *and* the "appearance" of *Cycloloma* in this location.

A member of the Chenopodiaceae family, *Cycloloma atriplicifolium* is a plant that thrives in disturbed and sandy soils and should be present in the vicinity of disturbed areas such as villages and archaeological sites. The species has been positively identified at only five sites in the Sand Canyon Locality, including Sand Canyon Pueblo (CCAC 2015a). At Roy's Ruin (site 5MT3930) a single seed was found in a kiva floor scrape sample dated to early Pueblo III. Located approximately 1 km south of Sand Canyon Pueblo, the Troy's Tower site (5MT3951),[66] a masonry tower with massive double stone and core walls connected to a subterranean kiva contained winged pigweed (an overwhelming relative abundance of 26 specimens for the area). It also had plants distinctive for their medicinal potential and a similar collection of domesticates (*Zea mays* and *Phaseolus vulgaris*). Evidence of violence and the postabandonment burial of a woman suggest that, like Sand Canyon Pueblo, it too shared a similar end. Varien (1999) proposes that the tower may have played a specialized role in

[66] The Troy's Tower sample came from the hearth and is one of two samples that yielded a particular constellation of plant remains that resonates in block 100: *Cycloloma atriplicifolium*, *Mentzelia albicaulis*, *Opuntia*, and *Plantago* seeds (*Plantago* is an ethnomedicine). An unidentified Capparaceae seed (perhaps *Cleome*?) was also recovered in a large bell-shaped pit. Charcoal from the tower floor ash included *Ephedra* (Varien 1999). All are pharmacologically active species and used in a variety of sophisticated medicinal applications today and in the past and a similar collection as that of block 100.

conjunction with SCP, its abandonment due to violence places it in the same violent context. Its plant remains markedly similar to last days at Sand Canyon Pueblo. Catherine's Site (5MT3967), excavated in sampling units, is located nearby (approximately 1.4 km). A flotation sample from its midden yielded a *Cycloloma atriplicifolium* seed. A vegetal sample from the fill of a bench in subterranean kiva 104 at Castle Rock Pueblo was identified as a *Cycloloma atriplicifolium* seed (Adams and Brown 2000). Adams (2008:80) reports a small burned jar filled with burned squash, *Cycloloma* seeds, and maize pollen near burials at Salmon Ruin that may have been "an offering to the spirits of the dead," a practice documented by Parsons (1996 [1939]:302).

Whiting (1939:32) provides some information of historic Hopi use of *koto'ki* or *Cycloloma atriplicifolium* (Spreng.) Coult. A traditional Hopi medicine, the plants were used in the treatment of fever, rheumatism, headache and "lightning sickness." *Koto'ki* is said to smell like lighting and lightning sickness comes from breathing its odour. The theme of lightning is mirrored in other ethnographies. Cushing (1920:630) reports that arrow shafts are considered an emblem of lightning. Flint clan medicine men cure lightning-sent diseases using lightning frames made of "lightning-blasted pine or spruce in order to impart the power of Lightning" (Parsons 1996 [1939]:378). (At Hopi, lightning frames are noted as made of *Amelanchier pallida* Greene (pale serviceberry [Whiting 1939]). Connection with the Bear is evident here: Flint and Fire curing societies are considered "Bear medicine" societies among the Tewa[67] (Parsons 1996 [1939]:133). Stevenson (1915:84) records that the Zuni call the plant *a'kwa lup'tsine* meaning "yellow medicine," a plant spiritually aligned with the Bow Priesthood. Similar to *Lycium, Cycloloma atriplicifolium* is linked with the mythic twin Warrior Brothers:

> This medicine (*Cycloloma atriplicifolium*) belongs to the grandmother of the Gods of War [Spider grandmother]. She gave it to them with instructions that when near the enemy they should bite off some of the blossoms of the plant and chew them, ejecting the mass into their hands and rubbing the hands well together. As soon as the Gods of War had done this a peculiar yellow light spread over the world, preventing the enemy from seeing how to aim their arrows truly.
>
> This medicine was exclusively in the keeping of the late Nai′uchi and his ceremonial brother, Me′she, who were the earthly representatives of the Gods of War. The secret of its use passed away with their death, as they did not see fit to confide it to others of the Bow Priesthood (Stevenson 1915:84).

[67] The Tewa are Tanoan dialect speakers of the Rio Grande Pueblos of Tesuque, Nambe, Pojoaque, San Ildefonso, Santa Clara and San Juan located near Santa Fe, New Mexico.

Cycloloma atriplicifolium and block 300 at Sand Canyon Pueblo

In their preliminary report on the plant and pollen record, Scott and Aasen (1985) report the identification of four uncharred *Kochia* seeds found with charred *Zea mays* kernel and fragments of cupule, *Pinus* nut hull and *Cleome* seed in the fill of a vessel found on the floor of room 303. *Kochia* (as *Kochia atriplicifolia* Spreng.) is a synonym of *Cycloloma atriplicifolium* (USDA NRCS 2015). Whether the uncharred "*Kochia*" seeds identified by Scott and Aasen are winged pigweed or another genera, their co-occurrence with *Cleome* in the context of a vessel is unusual. Block 300, itself is unusual. Located west of the spring and across the main plaza from block 200 on the western arm of the pueblo, it is at a short distance from block 100 (see Figure 6.3, p. 132).[68] The excavated kiva (kiva 306) was unusual in its simplicity, an almost pared down mimic of a kiva. The presence of refuse (nonstructure 314) beneath the floor of one of the kiva rooms (room 307), which probably extends beneath the kiva and rooms 308-312, indicates that this area was occupied earlier. There are no tree-ring cutting dates. Room 303 was inferred to function as a "storage room" with entry presumed to have been through a hatchway. Two vessels and several ground stone tools appear to have been stored here.

The plant remains mirror that of other blocks with the exception of the vessel in room 303. A burned spot located in the southeast corner of the room is thought to have been the remains of an ephemeral fire. Pollen samples from a subfloor pit near a metate and a collection of manos yielded moderately high concentrations of *Cleome* pollen (note also similar evidence in blocks 100, 200 and 500), with high frequencies under the manos (Scott and Aasen 1985). Although the provenience of the winged pigweed seeds differs from that of great kiva peripheral room 805, some similarities are shared. Both showed evidence of expedient fires containing seeds or near seeds that are identified rarely within 400 km of a densely populated Pueblo III landscape. The temporal associations are similar in that they are abandonment contexts. Ethnographically, the plant is associated with food, medicine, clans and spiritual themes. The naming of *Cycloloma atriplicifolium* as lightning medicine links the plant with war, fire, yellow medicine, and warriors as referenced in Stevenson (1915:84). If the historical record is any indication, the presence of this seed type could be the result of a distinctly cultural defensive strategy. The metaphorical connections suggest this plant was less likely a campfire cuisine as might be presumed.

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[68] Map 4077 Structure 306, aboveground kiva, Site 5MT765, Excavated Portion of Architectural Block 300, Plan view outlines the area. Made available courtesy of Crow Canyon Archaeological Center (CCAC 2015A): http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4077.tif&Zoom=25&Site=5MT765&MapNum=4077&SUNum=306&SUTyp=Structure&SUDesc=aboveground+kiva&StartingSUTypePage=Structure_Page&Crit=Kivas&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Structure_Page&RequestPage=MapList_Page. +

Midden 803: *great kiva trash*

The midden was uncovered in an excavation unit in the central east half of the kiva in a space that could have been a peripheral room if peripheral rooms were present and completely encircled the kiva or were planned. The extent of the midden is unknown. If it accumulated after construction of the rooms and the apparent abandonment of normal great kiva activities, the refuse would then reflect activities during the mid to late A.D. 1270s, based on the construction dates associated with the peripheral rooms and the transitional time frame assessed based on the transition in use of the D-shaped building. It is equally likely that the midden may have accumulated as the result of discard from the kiva during its intended purpose. The abundance and variety of remains recovered here are confusing in this regard if we assume that ceremonial and/or ritual activities no longer occurred in the great kiva. The faunal record provides evidence of numerous species, ones of particular interest include *Bubo virginianus* (great horned owl) and Falconiformes (vulture, hawk, eagle) and falcon-type birds (see Muir 2007; Muir 2007:Table 3), species that are historically related to important religious or ritual activities. The plant remains also reflect abundance and variety consisting of domesticates such as *Cucurbita* (gourd/squash) rind, *Phaseolus, Physalis* and *Zea mays* remains. *Juniperus, Pinus* and rose species woods were used as fuel. Similar to the trash that accumulated in the D-shaped building, the assemblage is similar for these later periods of use. The plant remains in the great kiva and D-shaped building indicate that domesticates and wild species continue to be used even in disordered contexts.

Room 813: *baby burial*

This room with its infant burial is a poignant reminder of the trauma of Sand Canyon Pueblo's demise. The room had apparently fallen into disuse prior to the end of occupation and only a very little area of the floor was exposed during excavation. An adult male of approximately 35-39 years old was found in the fill of the room. The infant, approximately 3-9 months old, was "carefully placed" here, near or with the remains of a young canine. The apparent burial of a young baby and puppy perhaps speaks to us of a family's tragedy as presumably the parents or the infant's grandparents buried a beloved child. Roof collapse filled the space.

There is a patterning of plant remains in the great kiva complex that led researchers to suggest a higher dependency on wild resources for food and an apparent decrease in the availability of fuel wood suggested by the variety of shrubs identified. The absence of *Artemisia tridentata, Chrysothamnus* and the prolific shrubby *Quercus* (oak, likely *Quercus gambelii*) that inhabits the canyon today is not necessarily unusual in this context. The lack of a roof on the great kiva and no evidence that roof beams were burned in latest occupation fires is an explanation for absence of shrubs that were typically dried on roofs within easy access for cooking fuel in the historic record. Certainly a concern for maintaining some kind of cultural order may well have been practiced, particularly when considering what was the most defensively vulnerable phase of occupation, a reality that would not have been lost on the residents.

Architectural block 1000—the "other" gateway block

One kiva, two kiva corner rooms, a two-storey D-shaped tower, two courtyards and six rooms were completely or partially excavated in block 1000. Portions of a midden and a surface were also sampled (Kuckelman et al. 2007). I evaluated samples from six depositional contexts consisting of firepits and trash in various rooms and surfaces. The map link is helpful in understanding how structures are laid out and allows for a picture of the occupation to emerge. [69]

The courtyard and several rooms in this block offer clear evidence of changing priorities. Located on the eastern arm of the pueblo, block 1000 partially encloses the main drainage and has one of the four defensive D-shaped towers identified for Sand Canyon Pueblo. Investigators estimate that construction may have started with the building of the site-enclosing wall or some part of the site-enclosing wall, although when this occurred here is unclear. Certainly the arc of the wall matches that of block 100 across the drainage. Based on tree-ring dates, one kiva (structure 1004) may have been built in either A.D. 1264 or A.D. 1266 and, for that reason, Kuckelman et al. (2007:Table 3) estimate that block was built about A.D. 1266, a time frame that is late when compared with dates for the tower in block 100 (structure 101) and the dates for some work on the great kiva. The tower in block 100 was built with the wall and the wall distinctively curves at that point. In block 1000, its tower is roughly adjacent and reflects similar positioning. If both blocks 100 and 1000 were built later, the metaphorical message of the "D," if indeed this was a deliberate strategy, would not have been in place until late. The construction of tower 101, so similar to the positioning of tower 1008/1019, suggests that this block, too, may have been earlier. An apparent change in room use is seen in the occurrence of more transient thermal features in unexpected contexts and the sealing over of other thermal features. Block 1000's obvious transitions, and there were at least two, occurred in very rapid progression if the construction dates were later. As with much of the village, timing is essential for understanding something of cultural evolution and the use and potentially changing use of plants.

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[69] Map 4121, Site 5MT765, Excavated Portion of Architectural Block 1000 provides a plan view of the block as excavated made available courtesy of Crow Canyon Archaeological Centre (CCAC 2004): http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4014.tif&Zoom=25&Site=5MT765&MapNum=4014&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=.

Block 1000 construction includes elements associated with ideological themes, such as the inclusion of niches that traditionally held “fetishes” in the historic period (Fewkes 1902). The sealed firepits of tower (1008/1019) hint at original purpose. Similar to tower 101, this tower also functioned as a special locale for organized activity at least in its earlier use. In his analysis of the faunal remains, Muir (1999; 2007) provides a compelling case for hunting and meat distribution in this tower also. The fact that tower 1008/1019 displays some evidence of the same, suggests that Muir’s assessment correctly identifies cultural content that shares similarity with the culturally prescribed distribution and discard associated with hunting activities, and I suggest, war ritual, in the historic period. The final use of the courtyard is from a working space to that of a midden (CCAC 2004: Middens, Nonstructure 1000). Some of the data collected for this block are synthesized here.

Kiva 1004: a “*catastrophic residence*”

Kiva 1004 is typical of six-pilaster aboveground Pueblo III kivas and is surrounded by a courtyard (Nonstructure 1016) and two kiva “corner” rooms (1017 and 1018). A large corner storage bin fills up much of the space of the southern recess of the kiva and a metate bin is present on the west bench (CCAC 2004: Kivas, Structure 1004). Two distinct firepits had intruded on the hearth; all had been used for an extended period of time, although the final firepit had been cleaned out. Vegetal samples from roof and wall fall were identified as *Juniperus*, *Pinus*, *Artemisia tridentata*, and *Chrysothamnus* charcoal, typical hearth fuel types. A flotation sample collected from the hearth fill yielded *Juniperus*, *Pinus* and *Prunus/Rosa* charcoal, four *Opuntia* seeds and four *Helianthus* achenes.

The kiva contained a variety of broken refuse items such as flakes, fragmented tools etc., on the floor. A number of slab metates were found on the benches. Similar to block 100, this is a site of the traumatic death of children. A child of approximately 8 years of age and an adolescent of approximately 12-15 years of age were killed or dumped into the kiva; both had sustained lethal skull fractures (Kuckelman and Martin 2007). Both suffered health problems—inactive porotic hyperostosis and cranial pitting, conditions that suggest relatedness (para. 73). They shared cranial pitting with another child (5-6 years old) found in room 1002. The kiva corner rooms were the sites of both deliberate burials and the traumatic death of an infant. Their remains also hint at debilitated health. If they are related to the individuals in block 100, there is a clear pattern of health problems in this family or extended family. Other rooms associated with kiva 1004 provide information about the last days and weeks of occupation, shifting priorities and the content of earlier deposits. Descriptive characteristics of the various areas are highlighted in headings and order of discussion is based on proximity to the kiva.

Room 1017: *"kiva corner" room burials*

This small room is adjacent and west of the kiva and is categorized as a kiva corner room (CCAC 2004). It has no architectural features and based on its size it may have been used originally, as most kiva corner rooms are inferred to be, as a storage room. The room served its final purpose as a burial room where four children, ranging in age from fetal to two years of age and one child two to six years of age were formally interred. An adolescent of approximately 15 years of age was also buried in this location. Two of the infants, similar to the infant in block 100, showed skeletal evidence of periostitis, as previously described, a condition when occurs in infancy is due to congenital treponemal disease (Whipple and Dunham 1938). It is life-threatening in infancy, causing fetal and infant death in 40 per cent of cases in modern populations (requiring an aggressive course of antibiotics to avoid severe disability or death)(Arnold and Ford-Jones 2000; Center for Disease Control 1988). A baby of approximately one years of age was found next door in the roof fall of room 1018.

Room 1001: room with bedrock feature

Room 1001 takes up the northeast area between the site-enclosing wall and room 1003. No thermal features were noted and other than a cluster of pecked depressions on the bedrock surface in the north corner of the room little in the way of material remains distinguishes this room. Faunal evidence is limited to a few bones of a grouse-type bird (Galliformes) and a rodent gnawed turkey bone. Two young adults (HRO 20 and 21) were found in the roof fall and likely perished on the roof, which collapsed over time. Both were approximately 20 years of age and suffered congenital premature cranial suture fusion that probably resulted in abnormal head shape. Depending on the timing of fusion, mental impairment may have been the result (Kuckelman and Martin 2007:para.73). HRO 20 also had a genetic anomaly of the sternum, a condition shared with HRO 12, a 15-year-old adolescent found in wall collapse of room 1005 nearby. Room 1001 shared a raised sill doorway with an unexcavated area to the northwest and another raised-sill doorway with room 1002 to the southeast. The two rooms were originally part of a larger room or space between the kiva courtyard and the site-enclosing wall. Their addition suggests the need for additional living space or rooms to provide ceremonial space. These rooms allowed for access to both the outer courtyard (see map link) and the tower.

Room 1002: the "*three-firepit*" room

Three original loopholes in the site-enclosing wall were blocked on construction of room 1002 indicating that the space was part of the courtyard that occupies the southern portion of the block. Tower construction likely occurred concurrently with the building of this and room 1003 or the larger room originally subdivided into rooms 1002 and 1003. The site-enclosing wall loopholes were replaced here with the construction of the tower (Kuckelman et al.:para.119). In addition there seems to have been a doorway that allowed access from room 1002 into the upper storey of the tower (structure 1019, above 1008). Access at ground level was from the main courtyard (nonstructure 1000) to the south over a silled doorway suggesting that protection from the elements was required. Evidence of multiple firepits, some of which had been used for some time, suggests that room 1002 was originally used for a number of activities (the Warriors' Room at Walpi comes to mind here), particularly with its access to the upper room of the tower. A cluster of three pecked depressions was noted in the bedrock surface in the north corner of the room. A flotation sample from an informal firepit (feature 1, south corner) yielded charcoal from *Juniperus* and *Amelanchier/Peraphyllum* (similar Rose family species). The other firepits were located in the east and west corners of the room. The west corner firepit had been built into an existing pit (CCAC 2004: Rooms, Structure 1002). Some pottery sherds were present in two of the firepits and on the floor surface. Material remains consisted of two sandstone disks, a two-hand mano, a chipped stone tool and a modified flake. The skeletal remains of a 5-6 year old child dropped through the hatchway were found on the firepit in this corner (CCAC 2004).

<u>Two-story tower 1008/1019: "*retrofitted defense*," an add-on-D-shaped tower</u>

Structure 1008 is the lower storey of a D-shaped tower that extends out from the site-enclosing wall and may be functionally associated with an unexcavated larger tower located on its southeastern flank. The tower was constructed after the site-enclosing wall was in place and was not planned based on the retrofitted doorway, punched through the wall. Loopholes in the wall in the vicinity of rooms 1001 and 1002 indicate that the tower was added later. The tower contained many useable objects that may have been deposited on its floor when the upper room collapsed. The main access was the raised sill doorway from courtyard 1000 immediately outside of rooms 1002 to the northwest and 1005 to the southeast. The ceiling of room 1008 is estimated to have been only 1.2 to 1.5 m in height and it is unlikely that the room served as a living area for this reason (CCAC 2004). The tower contained scattered human remains. Over time, the roof and second storey eventually collapsed and the upper walls covered the remains (CCAC 2004: Rooms, Structure 1008).

The addition of this tower onto the pre-existing site-enclosing wall indicates continued concern over defense. Muir (2007:para.47, 48-49) notes that concentrations of artiodactyl remains are found in kivas and towers, particularly in towers 101 and 1008/1019. The placement suggests that communal hunting and feasting activities of hunting or war-society groups occurred with access to meat limited to particular groups (Driver 2002; Muir 1999, 2007). I suggest that the timing is indicative of pre-harvest or around the time of harvest. The apparent lack of maize in the form of kernels in archaeobotanical samples here, similar to elsewhere could be interpreted as unsuccessful maize harvest, raided supplies or pre-harvest milled maize cuisine (Sutton and Reinhard 1995).

Because the upper storey of the tower (1019) collapsed into the space occupied by the lower storey (1008) it is challenging to interpret the purpose of the tower particularly in its final uses (CCAC 2004; Kuckelman et al. 2007). Vegetal samples collected from roof fall were identified as charcoal from *Juniperus*, *Pinus* and *Purshia*-types (rose species), typical fuel choices noted across the site and through time. A burned spot in a layer of roof fall and recorded as a thin layer of white ash that was fairly well confined and produced evidence of ground maize, cheno-am, *Physalis longifolia*, and *Portulaca retusa* seeds, likely originating from the room above (CCAC 2004: Rooms, Room 1008, Feature 3).

Room 1005: *two-firepit room*

Room 1005, located directly to the southeast of the tower, contained no evidence of roof beams leading to the conclusion that the room originally had no roof (CCAC 2004). The skeletal remains of an adolescent of approximately 15 years of age (HRO 12) were found in the wall fall. This individual shared a genetic abnormality of the sternum also recorded for HRO 21 found in room 1001 suggesting relatedness (Kuckelman and Martin 2007).

The room contained a slab-lined pit was located in the southeast corner that likely served for food storage. A few pottery sherds, a fragment or two of groundstone, and a single bone from a cottontail rabbit were the only material remains. A firepit of quite substantial size, which may have intruded into one or more floor surfaces, was located in the northwest corner of the room (CCAC 2004: Rooms, Structure 1005). A smaller firepit in the center of the room was also built into subsurface deposits similar to the corner firepit, but sealed over by a final surface. A flotation sample from this feature contained the ubiquitous *Juniperus* and *Pinus* and questionable identifications of *Fraxinus* (ash) and *Prunus/Rosa* charcoal. A single *Physalis longifolia* seed was recovered. An additional volume flotation sample taken from wall fall yielded *Juniperus* and *Ephedra* charcoal and *Plantago* seed. *Zea mays* cob remains and *Juniperus* and *Artemisia tridentata* charcoal were recovered in roof fall (CCAC 2015a). Two temporally distinct activities are accounted for in these samples, a pre-transitional deposit (the sealed firepit) and a latest activity burn feature.

Courtyard 1000

The courtyard in block 1000 is an outdoor area that originally served as a workspace (CCAC 2004: Nonstructure 1000). It borders the tower, rooms 1002, 1003, the kiva courtyard (1016) on the north, and rooms 1006, 1007 and 1005 on the south. Three rooms—1002, 1005 and the lower storey of the tower (1008)—had direct access to the courtyard.[70] Two firepits, a burned spot, and an architectural petroglyph/pictograph are features of the courtyard. Its final use was as a midden. There may have been a *ramada* (a roofed shelter) or a drying rack in the courtyard at one time prior to this later transformation. Three courtyard surfaces were recorded in the field notes (CCAC 2004: Extramural Surface, Nonstructure 1000): surface 1, a prepared surface; surface 2, below this surface; and a lowermost surface made up of construction fill that may have been compacted or represent a constructed surface. Based on a tree-ring sample from this lowermost layer, the surfaces of the courtyard are later than A.D. 1266, the refuse beneath, prior to that date.

Test trench kiva 1010

A trench excavation, kiva 1010 is located just south of block 1000 and overlooks the spring and west arm of the pueblo. The trench inadvertently partially exposed the remains of an adult, possibly female, on the floor of the kiva testifying to the violence of the final day. Some roof collapse was noted, possibly dismantling at some time, and the roof burned. Hearth samples were collected and the body left otherwise undisturbed. Faunal remains suggest cottontail was consumed in the final meal.

Block 1000 shares similarities in occupation with its gateway twin, block 100. The apparent relatedness between residents also hints at a possible ancestral relatedness with Pueblo Bonito (Kuckelman and Martin 2007).

Architectural block 1200—the "many plants" suite[71]

Block 1200 is distinguished by its construction dates and the contents of its midden, the most abundantly diverse accumulation excavated at Sand Canyon (Adams et al. 2007; Kuckelman et al. 2007). The block is located along the site-enclosing wall on the eastern arm of the pueblo to the south

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[70] Map 4123, Site 5MT765, Courtyard 1000, Surface 2, showing features associated with samples evaluated here, made available courtesy of Crow Canyon Archaeological Center (CCAC 2004) is linked here: http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4123.tif&Zoom=25&Site=5MT765&MapNum=4123&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Study+unit&MapPlan=Plan+View&MapProfTypDesc=.

[71] Map 4016 Site 5MT765, Block 1200 Topography details the layout of structures in block 1200 (shaded areas excavated), made available courtesy of Crow Canyon Archaeological Center (CCAC 2004) http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4016.tif&Zoom=25&Site=5MT765&MapNum=4016&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=. The block as excavated is outlined on map 4159*:* Site 5MT765 Excavated Portion of Architectural Block 1200 available at: http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4159.tif&Zoom=25&Site=5MT765&MapNum=4159&SUNum=1206&SUTyp=Structure&SUDesc=aboveground+kiva&StartingSUTypePage=Structure_Page&Crit=Kivas&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Structure_Page&RequestPage=MapList_Page

and at some distance from block 1000. Many of its buildings cling to the cliff face. One kiva, a circular tower, ten rooms, three kiva corner rooms, a courtyard and the midden were extensively excavated (Kuckelman et al. 2007). Four areas in block 1200 produced tree-ring cutting dates. Two latest cutting dates came from the kiva, which produced 27 cutting dates in A.D. 1242, three in A.D. 1260 and thirteen in A.D. 1262. The A.D. 1262 is estimated as the beginning of construction, the others inferred as re-purposed beams (Kuckelman et al. 2007: Table 3). Some of the rooms may also have been built in later episodes (para.133-134). Over time parts of the block seemed to have fallen into disuse. A deliberate burial of a young adult, possibly a female, was encountered in the excavation of the midden (1214). The block may have been abandoned due to the final attack (para.139), or the block was not fully occupied at the time. A review of the more interpretatively salient areas of the block is presented here.

Kiva 1206: a "*dual-ventilation system*" kiva

This fully excavated aboveground Pueblo III style kiva dominates the block as excavated. It has kiva corner rooms and is bordered by the site-enclosing wall to the east and a single row of rooms that separate it from the cliff and a very narrow cliff-side "courtyard." The kiva did not appear typical of small local kivas because of its dual ventilation systems: a subfloor ventilator tunnel in addition to the floor-level ventilation systems seen in other kivas at SCP. Only the twin kivas of the D-shaped building had this arrangement. There are also tunnels at the bench level that are unusual, providing access to hatchway entries of two corner rooms (structures 1219 and 1222). Abandonment was assessed as "leisurely;" that is, people seemingly stopped using the kiva and took their possessions with them (CCAC 2004: Kivas, Structure 1206). Faunal remains noted for the kiva consist of a small number of turkey, large birds (larger than mallards), small mammals and small birds (robin or smaller). One burnt black raven bone (*Corvus* sp.) was found in the fill of one of the bench segments. Evidence of unassociated refuse was present on the floor, probably underneath the hatchway. At some point, pothunters removed some of the fill (CCAC 2004: Kivas, Structure 1206).

Although the kiva appears to have fallen into disuse, another structure in block 1200 appears to have been used as a residence or cooking area. Room 1209 is situated to the west of the kiva and is part of the room block between the kiva and the cliff. Its north wall forms part of what once were rooms 1212 and 1204 (now the midden 1214). It is a relatively large rectangular room with a hearth, similar to rectangular kiva 107. The hearth had been heavily used (CCAC 2004: Rooms, structure 1209). Only samples from the wall and roof fall have been analyzed. These contained partially charred *Juniperus* wood, *Pinus* charcoal and a *Zea mays* cupule. There was no evidence of a roof in the fill of the room. In the fill above the kiva corner rooms (nonstructure 1218), however, burned roofing debris and numerous economically important plants are noted (CCAC 2004: cultural deposit, nonstructure 1218, type unknown). Obviously the roof was used as an activity area, bones of large birds, turkey, squirrel and cottontail were scattered there. Two *Canis* (dog/wolf/coyote-type) bone fragments are documented. Ground stone tools include cores, flakes, peckingstones, a projectile point, a complete slab metate and several two-hand manos. Remains of pottery jars and bowls of various types are also recorded. On or near the floor surface vegetal samples provide an interesting collection of plants in this location. One specimen of *Juniperus osteosperma* (scale leaf) and many small charcoal fragments of *Artemisia tridentata, Atriplex* (saltbush), *Chrysothamnus* were also identified. A tentative identification of *Lycium* and *Purshia* charcoal is also noted (CCAC 2015a). Unusual seed types include an unknown Solanacae-type (Potato family) and *Stipa/Oryzopsis hymenoides*. A seed cache of *Penstemon* (penstemon; an unusual abundance of over 500 specimens) and *Purshia* (approximately 2000 specimens) indicate that activities on the roof included collections of seeds in the fall season. I suggest that these seed caches indicate that the block was occupied and in use prior to the attack. Previously, approximately 100 *Purshia* seeds were located in the roof fall and mixed refuse of kiva 1004, approximately 100 specimens are recorded in the roof fall and mixed refuse of D-shaped tower lower story room 1008 (CCAC 2015a). As earlier noted, *Lycium*, rarely recovered in the Sand Canyon Locality, was also found here.

Great Basin groups ground the seedcoats of *Purshia tridentata* (bitterbrush) to make a violet dye (Moerman 1998:456). For Pueblo groups, purple dye was colouring for the imitation bean pods used for the *Powamuy* kiva crop (see footnote 57, pp. 188-189). Numerous Native American groups used the plant for its seeds, leaves and fruits as ceremonial emetics and medical applications for the treatment of coughs and the washing of wounds. Both hint of antibacterial qualities in the plant. Recent scientific research has indicated that *Purshia* has medicinal potential.[72] The seeds are not recorded as eaten. Similar to the collection of pharmacologically active plants found in block 100, the seed caches and unusual remains in block 1200 suggest that ceremonial or medical use of particular plants consistent with clan-owned medical knowledge are present. A similar interpretation can be made for *Penstemon* seeds. *Penstemon* species are also known as Pueblo medicine or drugs (Moerman 1998:383). These are also associated with the *Powamuy* ceremony and the east direction. Stevenson (1915:95) records the Zuni name for the *Penstemon* plant as “jackrabbit all root,” its root chewed and rubbed over rabbitsticks to ensure successful hunting. Recent study has shown that at least two species of *Penstemon* (*P. gentianoides* [Kunth.] Poir. And *P. campanulatus* [cav.] Willd,;

[72] Phytochemical studies on extracts from stems of *Purshia tridentate* DC (antelope bitterbrush) show inhibitory activity on the human immunodeficiency virus (HIV-1 type)(Nakanishi et al. 1994).

Plantaginaceae/Plantain family) known to grow in mountainous regions of the U. S. and Mexico were used by indigenous peoples for drugs to treat chronic inflammation and rheumatism (Dominguez et al. 2011).[73] The themes of hunting and war resonate in block 1200 in latest occupation contexts as much as they do in blocks 100, 300 and 800 where particular plants support a fall season hunt and protective medicine.

Midden 1214: the "*smoldering trash dump*"[74]

Midden 1214 has been aptly described on a provenience data record provided to me by CCAC as a "smoldering trash dump." The refuse discarded into this space is presumably from the kiva, the tower and associated rooms. Midden 1214 has a complex renovation history. The midden fills two earlier and separated rooms, 1204 and 1212, which were originally one large room. This room occupies what was plausibly a plaza area that separated the kiva suite from a circular tower that clings to the cliff edge. After the room was subdivided a set of three mealing bins and a dividing wall were added, creating a separate mealing room and inferred "storage" room (CCAC 2004: Rooms, structures 1204, 1212). Sometime after A.D. 1265, the rooms became used as a midden. A deliberate interment of a young woman (?)(Kuckelman and Martin 2007) was encountered within the fill (CCAC 2004: Middens, Nonstructure 1214). These two important structures, mealing and storage rooms in the historic period were ritually and cosmologically significant, in block 1200 in later occupation become spaces to put refuse.

Samples from the midden do not reflect food scarcity but rather, abundance and a lack of concern for food waste during a time that has been associated with drought and resource stress. Similar to the remains found in room 1205, midden 1214 has a large plant assemblage in various distinct layers (descriptions and analysis are presented in chapters seven, eight and nine). The faunal assemblage consists of many bones of turkey and large birds, *Lepus* sp. (jackrabbit or hare) and a few medium sized mammals (deer size or smaller), wood rat and cottontail. Unusual remains consisted of single specimens of quail (Phasianidae), blue grouse (*Dendragapus obscurus*) and a few bones of

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[73] Zajdel et al. (2013) report several native species for antimicrobial effects on Gram-positiv, Gram-negative bacteria and some human pathogenic fungi.

[74] Map 4179 Site 5MT765, Midden 1214, Stratum 1-2 provides a plan view of the two rooms (rooms 1212 and 1204) that became the site of midden 1214, made available courtesy of Crow Canyon Archaeological Center (CCAC 2004):
http://www.crowcanyon.org/researchreports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4179.tif&Zoom=25&Site=5MT765&MapNum=4179&SUNum=1214&SUTyp=&SUDesc=&StartingSUTypePage=Middens_Page&Crit=Middens&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Middens_Page.

Canidae (dogs/wolves), and *Canis* sp. (dog/wolf/coyote). Many, varied and typical SCP groundstone tools are recorded for this midden.

Room 1205: "*tchamahia* and storage" room

Located northeast of the kiva, room 1205 is two-storied, large and rectangular. It was entered through a hatchway in the roof. It had three niches. Excavation notes indicate that the second storey collapsed and a variety of artifacts were either associated with the floor or the collapsed floor of the room above. No thermal feature was found and most artifacts were encountered in sediments above the floor in the southeast corner of the room near, or under, what is inferred as the hatchway access. Evidence of coiled basketry, a gourd vessel, shaped pieces of wood, reed grass "cigarettes," possibly a fragment of a bow, and a *tchamahia* are documented (CCAC 2004: Rooms, Structure 1205). Flotation and vegetal samples produced many and varied plant remains that confirm a similar abundance of plants as the midden. All seeds and achenes identified in room 1205 are uncharred and relatively abundant in quantity testifying to excellent preservation. For example, the count for *Scirpus* achenes is 97 specimens; *Physalis longifolia*, 232 seeds whereas the *Opuntia* seed count was 9 specimens. The plant remains in room 1205 provide evidence of a variety of fall season food plants and a range fuel wood and worked materials.

Architectural block 1500—the "twin" kivas[75]

The most unique and intricate structure at Sand Canyon Pueblo, this "twin kiva" complex is situated on the western arm of the pueblo near the south canyon rim. The map link provided is critical for understanding the layout of block 1500.

A wall bisects the interior "D" into a space of roughly equal halves. On the outside, a large double wall made up of rooms is constructed in arc, portions of which were excavated. Partial excavation also included opposite halves of each of the two kivas that occupy the interior of the

[75] Map 4019 Site 5MT765, Block 1500 Topography details the excavated portions of block 1500, made available courtesy of Crow Canyon Archaeological Center (CCAC 2004): see over. http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4019.tif&Zoom=25&Site=5MT765&MapNum=4019&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=. Excavated portions of the D-shaped building are highlighted in Map 4196, Site 5MT765, Excavated portion of Architectural Block 1500 made available courtesy of Crow Canyon Archaeological Center (CCAC 2004): http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4196.tif&Zoom=25&Site=5MT765&MapNum=4196&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Architectural+block&MapPlan=Plan+View&MapProfTypDesc=.

building. I evaluated a number of samples from trash accumulations and a firepit collected from the D-shaped building. The plant assemblage from all sources is similar in content and abundance to that of block 1200.

Ortman and Bradley (2002) make a compelling argument for an apparent heightened symbolic nature of the east kiva versus the west kiva and the pathways of movement within the building that mimics the circular nature of Puebloan cosmology, Emergence symbolism and migration. More so than the great kiva, the D-shaped building reflects phases of what I have termed "ideological expansion" and "transition." The message of the architecture of the D-shaped building suggests a social identity that includes a leadership structure meant to impress beyond its protective walls. The "abandonment" sequence of both great kiva and D-shaped structures consists of a period of non-residency evident in the accumulation of naturally deposited sediments followed by a transition to more mundane concerns with the introduction of mealing bins in each kiva and extinguishing pits and a large floor vault (CCAC 2004 Kivas, Structures 1501, 1502).

Distinctive structures such as the great kiva and the D-shaped building are also found in both large and small late Pueblo III sites and "suggest more active mobilization and display of social power," than we see in earlier periods (Lipe 2002:223). The building of peripheral rooms around the kivas of the D-shaped building and that of the great kiva at Sand Canyon Pueblo suggest a more elaborate display than at any other site in the Sand Canyon Locality, where at least one D-shaped building had no interior kiva. The Sand Canyon Pueblo D-shaped building transitioned sometime after A.D. 1270s (I am suggesting by ca. A.D. 1275 based on re-surfacing events that I assume are annual), the social power and underlying metaphor we associate with such buildings was seemingly replaced. The logical conclusion is that a leadership structure also faltered.

Kuckelman (2007b: para.23) suggests the building in its shape could reflect an early "Bow" warrior society. Clearly the D-shape was intentional. The D-shaped building kivas are unique in construction with subfloor ventilation tunnels and the more typical floor-level ventilation systems seen in other SCP kivas (the only other known kiva that shares this configuration is kiva 1206 which suggests to me a connected group of people with similar construction styles). Pit features in both kivas and a large floor vault in kiva 1501 has been assessed as a possible "foot drum" (CCAC 2004: Kivas, Structure 1501) similar to those found in the massive ceremonial kivas of Chaco Canyon (Casa Rinconada especially). The eastern kiva (1501) is oriented to take advantage of the rising sun. The ethnographic record confirms what Ortman and Bradley (2002:61) propose for the D-shaped building which is that the orientation serves for "keeping of the agricultural calendar" much like the obligations for such matters held by Bow priests and leaders in the historic period. I present ample evidence to support this contention and that the building sequence was intentional in a way that captures the essence of Pueblo cosmology.

The construction of east kiva 1501is estimated based on tree-ring cutting dates as beginning circa A.D. 1261. The peripheral rooms were also built at this time, estimated at A.D. 1260-1261 (Kuckelman et al. 2007:paras.140-156). The western kiva 1502 was constructed some ten years later, estimated circa A.D. 1270. The delay is intriguing. If the dates are accurate, ten years is a long time to see the full metaphorical content of the D-shape and its associated functions. It would require a labour force that continued to buy into the initial concept of the building, either delaying construction or deliberately taking their time. The second kiva was not an afterthought, the space it occupied made up half the building.

To understand the D-shaped building is to understand Sand Canyon Pueblo and the social ordering of the occupation. In the sections that follow, I highlight aspects of the building that demonstrate clear links to Pueblo religion. I divide the discussion that follows, as the building was constructed, into two halves, an eastern and a western half for the purposes of exploring these connections.

East kiva 1501: the elaborate earlier kiva

The east kiva is the more elaborate of the two kivas in the D-shaped building (Ortman and Bradley 2002). Only the western half of the structure was extensively excavated. Similar to kiva 1502 (the later west kiva), it was built above ground but, unlike other Sand Canyon Pueblo kivas, it has several unusual and elaborate features: a large floor vault, floor pits (two made with pottery mugs, one rectangular), and a subfloor ventilator tunnel in addition to the normal floor-level ventilation system of other SCP kivas (the only exception to this dual ventilation system is kiva 1501 and kiva 1206 in block 1200). Entry into the kiva is assumed through the roof and/or an unexcavated doorway on the east side of the building, or through the west entry and successive peripheral rooms. The large floor vault takes up a considerable amount of space in the western half of the building. The apparent post-holes of the vault were repurposed at some point with the placement of two Pueblo III White Painted pottery mugs (one rectangular) without bases inserted into the empty holes. The rectangular mug was painted with black geometric shapes similar in form to a similar rectangular mug of block 100. Only three rectangular mugs are recorded for Sand Canyon Locality sites that I am aware of. These include the rectangular mug in kiva 1501, which is quite elaborate, another in kiva 102 decorated with closely oriented diagonal lines and less formal in decoration and another that shared a striking similarity to the east kiva’s mug with a similar black and white geometric pattern. This mug was found at Yellow Jacket Pueblo (provenience unknown).

The history of the east kiva includes several episodes of replastering of walls and floor. Sometime later, no doubt after the west kiva was completed and resurfaced multiple times, the east kiva's floor vault was filled in and plastered over. A metate bin was added and many ground-stone tools and domestic trash accumulated (CCAC 2004: Kivas, Structure 1501). Scattered human remains were found in the latest episode. The roof was burned; the upper walls collapsed and naturally deposited sediments accumulated. Roof fall layers contained charcoal of *Juniperus* and *Artemisia tridentata*. A flotation sample from roof fall yielded *Juniperus* and *Artemisia tridentata* charcoals, and charred cheno-am and *Portulaca retusa* seeds, these remains could have been on the roof prior to its collapse. The original hearth contained *Juniperus* charcoal and cheno-am seeds (a relative abundance of 39 specimens). The firepit contained 120 specimens of cheno-am and *Juniperus* charcoal. The faunal remains found inside the kiva on the latest surface below wall fall and rubble includes a relative abundance of turkey, squirrel, cottontail and small mammals. Distinctive faunal fragments include a single bone of *Canis* sp. (dog/wolf/coyote) and a single bone of Corvidae (jays and crows) found on one of the kiva benches (bench segment 2), a ringtail/civet cat (*Bassariscus astutus*) mandible on another bench (bench segment 6) and a bone fragment from Strigiformes (owl) and a *Urocyon* or *Vulpes* (fox) femur were found in the fill of bench segment 3 (CCAC 2004, Kivas, Structure 1501, Faunal Analysis).

<u>West kiva 1502: less elaborate later kiva</u>

The west kiva (structure 1502), like its eastern counterpart was also constructed above ground. Tree-ring cutting data suggest it was built or remodeled circa A.D. 1270 (Kuckelman 2007: stem-and-leaf plots). Only the eastern half of this kiva was fully excavated. It is unique for its remodeling events: walls were re-plastered multiple times; many floor pits were sealed by a series of prepared and re-use surfaces. Kiva 1502 shared similar dual ventilation systems as both kiva 1501 and kiva 1206. A tall silled doorway through the bi-wall opened onto the plaza (nonstructure 1500) and permitted direct access with the outside and the peripheral rooms. This doorway was later made smaller and narrower, presumably an attempt to restrict access. The doorways that permitted entry through the various peripheral rooms were also blocked at some point making movement between the rooms impassible using doorways.

The subfloor ventilation tunnel in kiva 1502 was filled and a large roofed pit structure was built into the fill. Similar to kiva 1501, a metate bin and numerous stone tools and domestic trash were added. The structure was briefly re-used after a period of time as evidenced by a burned spot on top of naturally deposited sediment on the floor in close proximity to the original hearth. At abandonment or post warfare, the roof was burned, the walls eventually collapsed and sediment accumulated on the debris. Although less elaborate than its older "twin," kiva 1502 is distinguished by the early burial of a dog in the area in front of the doorway, placed carefully under plaza surfaces and covered by a stone slab. The kiva also saw significant use, the re-plastering of its walls at least four times, attests to a well-appointed space and concern for its upkeep (Kuckelman 2007: para.156).

The faunal record for kiva 1502 differs from the east kiva in that most remains in kiva 1502 consist of a scant amount of turkey, large birds (larger than mallards) and cottontail bones. Unusual remains were also identified. The ventilation system fill contained a maxilla fragment from a *Canis* sp. (dog, wolf or coyote). In refuse on the latest floor a complete dog or wolf mandible was identified. One fragmented bone of a jay/crow (Corvidae) was found in the fill of one of the kiva benches (CCAC 2004, Kivas, Structure 1502, Faunal Analysis). The plant record is based on vegetal samples from the latest surface (surface 1) identified as *Juniperus*, *Pinus*, *Artemisia tridentata*, and *Chrysothamnus* charcoal. One vegetal sample consisted of *Populus/Salix* charcoal. Material collected from the surface of the floor included a "stick mat" and a few charred cheno-am seeds. The hearth contained *Juniperus*, *Pinus* charcoals, seeds from cheno-am and *Opuntia*, and a single *Zea mays* cupule, recovered in a flotation sample. A burned spot located on a layer of washed-in sediment contained *Juniperus* charcoal and an unusual collection of seeds: cheno-am, *Physalis*, *Polygonum* (bindweed-type), and *Scirpus* (bulrush-type) achenes. A vegetal sample from below the fourth capped or prepared surface in this kiva was identified as *Juniperus,* Roasaceae-type and *Lycium* charcoals.

The *Polygonum* achene is a new identification for the SCP and for much the Sand Canyon Locality. Only a single specimen is noted for Wood's Canyon Pueblo located nearby (CCAC 2015a). The effects of subsampling are a plausible explanation for the visibility of the plant. *Polygonum* has garnered increasing interest in the scientific community for its ethnomedical applications in the treatment of many diseases (Nkuété et al. 2015).[76] The use of leaves and roots of *Polygonum* might be expected to leave behind only evidence of the seeds in archaeological sites. Similar to *Lycium*, little detail is documented for use of the plant by historic Southwestern groups, suggesting under-reporting for both these pharmacologically active plants. Various species of *Polygonum* were used as drugs for ceremonial medicine, gastrointestinal, urinary and kidney problems, rheumatism, wound healing,

[76] Well known in Chinese medicine for its use in the treatment of liver disease and as a salve for traumatic injuries, *Polygonum* is used in ethnomedicine today as a cure for hepatitis, gastrointestinal disorders, venereal diseases and skin infections (Nkuété et al. 2015:3). In other parts of the world various species of *Polygonum* are used in the treatment of colds, influenza, swelling, rheumatism, to control several bacteria and fungi, ulcers and gingivitis. The roots and leaves are used in different applications. In contemporary clinical studies extracts from several species are shown to produce anticancer activities for a range of tumours. *Polygonum hydropiper* (swamp smartweed), a native to Arizona and New Mexico, has been found to be an effective antioxidant.
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colds and as an oral medicine (Moerman 1998:422-424), all conditions apparently suffered by the residents of Sand Canyon Pueblo.

Pueblo twins: the twin kivas and local theory of the "artifact"

Whiteley (1998:13, emphasis in original) cautions anthropologists that, "anthropology needs to use local knowledge as local *theory*," as a method for capturing something of the viewpoints and perspectives of the "originators." The same is true of archaeology. A *local* theory of the "artifact" begins with ethnography, a version of the "originator." In the case of the D-shaped building, the ethnographic record is particularly illuminating. The architecture of the two kivas makes a powerful statement, particularly when considering the ethnographic importance of twins in Pueblo culture and the differences in the timing, positioning and embellishment of the two kivas. Using Whiteley's concept of *local theory,* the "twin" kivas mirror the metaphoric significances of the twin War god brothers of Hopi and Zuni, mythic brothers who persist in their influence into the contemporary enactment of religion and its obligations. The earthly roles of the War Brothers assumed by important leaders into contemporary times. The configurations of the kivas are deliberately build "identities" created to visually reinforce mythic and social power and capability.

The twin kivas are particularly well suited to ethnographic analogues when considering the concept of the "Bow" and early Bow societies as proposed by Kuckelman (2007) for Sand Canyon Pueblo. In Parson's (1996 [1939]) Zuni ethnography, her informants reported that "when the early people emerged into this world, the twin War Brothers sat one on each side of the sipapu[77] and gave a hand" helping the people enter into the Fourth World (184). These mythological icons established the curing societies, cultural laws and obligations and "they gave the people their plan of life" (183; 213). For the Hopi, the Twin War Gods are associated with the lion, bear, wildcat and wolf, figures prominently displayed on the four walls of the Warrior's Room at Walpi, as reported by Fewkes (1902). The brothers gave the "watercourses, hardened the ground" and placed the stars and moon (184; 213). They feature in narrative and ceremony, their power extending to contemporary religious obligations. They share a deep history in the pantheon of Pueblo cosmology.

Ferguson and colleagues' (1996) description of the Zuni's efforts to repatriate the stolen images of the Twin War Brothers that have been illegally removed from Zuni shrines over the decades, speaks to a version of Whiteley's prescription for "local theory" when considering how different people view and relate to their artifacts (Wobst 2010:18) and what the Warrior Twins signify

[77] The sipapu is a small hole in the floor of a kiva and provides symbolic access to the lower world (the place of Emergence) and has been identified in prehistoric kivas (Bahn 2001:412).

for Pueblo people. The images of the stolen War Brothers have ended up in museums and private collections, much to the horror of the Zuni (Ferguson et al. 1996:252).

The power of the War Twins is demonstrated in the deep concern of Zuni people for the brothers' images, the carved sculptures called *Ahayu:da*. These are powerful and animate representations that embody sacred knowledge and are "crucial to the performance of [Zuni] religion" (Ferguson et al. 1996:255). The *Ahayu*:*da* must be dealt with in prescribed and highly sensitive ways, and they must be allowed to disintegrate into the earth at open shrines. They can only be handled by those with exceptional knowledge, knowledge acquired through proper initiation (264). Being preserved and displayed in museums or, considered "art" by private collectors for prestige, is an anathema. Their removal from sacred shrines is seen as the contemporary cause of human tragedy around the world: war, violence and natural disasters:

> *Ahayu:da* are twin deities with great power. They are associated with prowess and physical skill, and they also serve as protectors of the Zuni people. Many non-Zunis refer to *Ahayu:da* as "War Gods" but their role in Zuni culture encompasses a much wider range of concerns than simply war. Images of the *Ahayu:da* are created in the form of cylindrical wood sculptures at the winter solstice and for the less frequent ceremonies held to initiate new Bow Priests or commemorate the Bow Priesthood. Members of the Deer Clan cooperate in the creation of *Uyuyewi*, the elder brother War God, while members of the Bear Clan undertake the creation of *Ma'a'sewi,* the younger brother... After their creation, the *Ahayu:da* are entrusted to Bow Priests who install them at two of a series of shrines surrounding Zuni Pueblo determined by a ritual sequence of rotation. When the newly created *Ahayu:da* are set in the shrines they replace the previously installed deities, which are respectfully placed on an adjacent pile of "retired" War Gods. These retired *Ahayu:da* retain an important role in Zuni ritual. All *Ahayu:da* are to remain at their shrines exposed to natural elements until they disintegrate and return to earth (Ferguson et al. 1996:251-252).

In their patiently persistent efforts to return these cultural icons their shrines Zuni Deer and Bear clan leaders and Bow Priests, petitioned museums and other collections through enacting a Tribal Resolution to reaffirm the significance of the images. This repatriation effort was initiated years before the passing of NAGPRA (North American Graves Protection and Repatriation Act) in 1990 and stands as a compelling example of how ignorance of cultural mores can impose great harm. The clan leaders' actions reaffirm the significant spiritual and metaphorical nature of the War Brothers and their imagery (Ferguson et al. 1996). Waters (1977:4-5) describes the Hopi twin brothers, as *Pöqánghoya*, the brother who "keep[s] the world in order" and *Palöngawhoya*, "the echo," (see also Stephen 1929:14) as the one who sends out sound that carries the message of the Creator. "Twins as everybody knows, have a special power and are called *chöviohóya*, young deer" (73). Cushing (1920:24) records the following description of the birth of the "twin brothers of light:"

> The Ancient Sun pitied the children of Earth. That they might speedily see his light, he cast a glance upon a foam-cap floating abroad on the great waters. Forthwith the

> foam-cap became instilled with life, and bore twin children, brothers one to the other, older and younger, for one was born before the other. To these he gave the *k'ia-al-lan*, or "water-shield," that on it they might fly over the waters as the clouds, from which it was spun and woven, float over the ocean; that they might blind with its mists the sight of the enemy as the clouds, darken the earth with rain-drops. He gave them for their bow, the rainbow, that with it they might clear men's trails of enemies, as the rainbow clears away the storm-shadows; and for their arrows gave he them the thunderbolts, that they might rive open the mountains, as the lightning cleaves asunder the pine trees, and then he sent them abroad to deliver, guide, and protect the children of earth and the Sky Father (24-25).

Whiteley's (1998:113) descriptions and analysis of ideational complexes present in Hopi naming conventions are, as he states, "more fully embodied" in mythological narratives (1998:113). He notes, with clear regret, "it seems to me that any separation of myth from its empirical grounding in social, cultural, and historical contexts seriously vitiates culturally significant interpretation" (114). The persistence and contextuality of Pueblo religious belief can be seen clearly in the repatriation efforts of the Zuni *Ahayu:da* and must be viewed as evidence of the deeper realities of how the Zuni and other pueblo people relate to their artifacts as being quite separate from how archaeologists may view artifactual evidence and inferences. Being human and living a "good life" in the historic and contemporary Pueblo world is conceived of and inhabited within a deeply interwoven spirituality, a world dependent on very specific human action and intervention. Returning the *Ahayu:da* to their rightful place—retiring them to their original shrines to disintegrate, return to the earth and become physically invisible—provides clues for the apparent "lack of" expected archaeological artifacts. This "absence" is not necessarily the result of pot hunting but of original intention. The return of such influential images from collectors through active engagement and negotiation is an attempt to redress the balance, to allow the brothers to disappear and be cyclically replaced. Perhaps the most culturally potent imagery in ancestral times is that certain things were never intended to be visible at all, certainly not visible to the uninitiated. The mythic Warrior Brothers are key to my interpretation of the D-shaped building.

Cushing's (1920) observations of Zuni thought as "the use of resemblance as a principle of cause and effect or a means of determining effects" is reiterated by Parsons (1996 [1939]:88) as a phenomena of "like causes like." This relationship can be seen in Whiteley's (1998:113) description of the rising sun:

> The personified (male) sun [the father of the Warrior Twins], Taawa, rises by climbing out of the kiva in the east. At the top of the kiva ladder, he puts on a gray foxskin tied to one of the ladder-poles, at which point the gray dawn light appears. He then puts on, from its position on the ladder pole, a yellow foxskin, creating the

> yellow dawn light, before beginning his journey across the sky to a western kiva, into which he descends at dusk (Voth 1903:351; [Voth 1905b:1]).

Malotki's (1993:431) translation narrated by Lomatuway′ma et al. confirms the same:

> According to Hopi mythology, the sun god emerges from his kiva in the morning carrying a fox skin. He puts the skin up on top of his kiva, at which time gray dawn appears. This particular fox is called Gray Fox.

Beaglehole (1937:27) records the divisions of the earliest hours of the Hopi day as, "the morning star rises;" "the grey dawn," and the "dawn becomes yellow." The geographic location of the D-shaped building is situated to capture the light of the morning sun as it rises in May (Ortman and Bradley 2002) and is suggestive of deeper connections with historic Hopi concepts when considering the significance of the gray and yellow dawn. Whiting (1939:45) identifies directional orientation and colours that fit with the growing dawn colours of the rising sun. The northeast is associated with the colour white; the northwest direction is associated with the colour yellow. The rising sun would appear as white/grey dawn from the roof of the east kiva, and seen as more clearly yellow, as it travels higher in the sky. The presence of fox (*Urocyon* or *Vulpes*) in the fill of bench segment 3 in the east kiva is intriguing in this context. To explore these ethnographic analogues further, the refuse that accumulated under the plaza surfaces outside the west kiva (1502) and the east kiva (1501), offers additional evidence of a special focus for each of these buildings.

Plaza 1500: multiple use surfaces, trash accumulations and main entry into the peripheral rooms[78]

To enter the west, less elaborate, kiva 1501, one passes over a series of plaza surfaces that occupy the space in front of what was once a tall doorway on the western half of the building. Two test trenches were excavated in the vicinity of this doorway (specifically, segment 2). The analysis of segment 2 consisted of the excavation of multiple layers of refuse deposited on successive surfaces (CCAC 2004: Extramural surfaces, Nonstructure 1500). The refuse content is interesting here in comparison with the refuse that accumulated on the east side of the D-shaped building. There are differences.

Upper layers of the west plaza consist of modern ground surface and two strata of wall fall. Vegetal samples from these layers produced *Juniperus* charcoal and some partially charred wood, a *Zea mays* cob fragment and a variety of uncharred but likely ancient material: *Atriplex* wood, a

[78] Map 4199 Site 5MT765, Nonstructure 1500, Segment 2, Stratum 6 (Trash Deposit), showing the dog burial, sample provenience, associated doorways and the unexcavated portion of kiva 1502, made available courtesy of Crow Canyon Archaeological Center (CCAC 2004): http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4199.tif&Zoom=25&Site=5MT765&MapNum=4199&SUNum=&SUTyp=&SUDesc=&StartingSUTypePage=&Crit=&RequestPage=Chooser_Page&RequestPage=SelectMapGroup_Page&RequestPage=WholeSiteMapList_Page&MapType=Digital+Maps&MapScopeCode=Study+unit&MapPlan=Plan+View&MapProfTypDesc=.

Cucurbita seed, *Juniperus* seeds (15 specimens) and *Pinus* seeds/nutshells (20 specimens). Directly below an ephemeral re-use surface numerous plant remains were recovered that are interspersed with rubble presumably from construction. Vegetal samples here were identified as *Juniperus*, *Pinus*, and Rosaceae-type charcoals, uncharred seeds from *Juniperus* and *Pinus*, some unidentified organic material and *Zea mays* cob fragments. A flotation sample from the same strata produced a variety of charred taxa: *Juniperus*, *Prunus/Rosa* charcoals, *Pinus* (bark scales only), *Juniperus* (likely *Juniperus osteosperma*-type) twigs with scale leaves (an unusual abundance of 50 specimens), a *Zea mays* cupule and seeds of cheno-am, *Physalis longifolia*, *Opuntia*, *Stipa/Oryzopsis hymenoides*, and *Ephedra* stems (12 specimens). Another cultural surface was noted in the western portion of the segment 2 excavation unit that yielded additional taxa. Charred remains from a vegetal sample were identified as *Juniperus* (seed), abundant *Zea mays* cob remains and more than 50 specimens of maize glumes suggestive of processed corn. A flotation sample produced an abundance of organic material (70 specimens of an unknown type). In addition to the ubiquitous *Juniperus* and *Pinus,* charcoal of *Prunus/Ros*a-type and *Ephedra* charcoal were identified. There was a relative abundance of *Juniperus* twigs. Poaceae stems, Cucurbitaceae (gourd family) rind and maize kernels and cob segments make up the domesticated remains. Seeds of cheno-am, *Opuntia, Physalis longifolia, Portulaca retusa,* and *Stipa/Oryzopsis hymenoides* were also located here. It is in this stratum that the dog burial was located. The lowermost strata below an additional prepared surface, contained charcoal identified as *Juniperus,* Rosaceae-types (unknown type and *Cercocarpus*). From early layers it is clear that, in addition to ground and whole maize, *Cucurbita* was also discarded in this location. The variety of wild seeds exemplifies the typical Pueblo III diet reported by Reinhard (2006) and Minnis (1989). It appears that ground maize and wild seeds and other domesticates were used in or around the D-shaped building.

The faunal remains found in association with the plaza in this location yielded an assemblage dominated by turkey and cottontail and a wide variety of small, medium-sized and large animals. The collection also included rare evidence of *Buteo* sp. (hawks), Corvidae (jays and crows), *Corvus corvax* (raven), Falconiformes (vultures, hawks and eagles) and Passeriformes (perching birds). These types of remains are limited to the D-shaped building and blocks 100 and 1000 and ethnographically are associated with spiritual themes (Muir 1999, 2007). Early in the building's use, people carefully buried a domesticated dog (*Canis familiaris*) under a slab at the entryway to west kiva 1502, providing clear evidence that this dog, at least, was special.[79]

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[79] Shields Pueblo (Site 5MT3807) located approximately 10 km from Sand Canyon Pueblo, shows a different pattern of canid remains. Rawlings and Driver (2005:186) conclude that domesticated dogs "dominate the carnivore assemblage," with few wild carnivores represented by *Canis* sp. (dog/wolf/coyote; 207 specimens),

Midden 1506: east kiva refuse

Located on the east side of the D-shaped building, the refuse is thought to have originated from the east kiva (1501) and the east side bi-wall rooms. A tree-ring sample collected from the midden produced a date of A.D. 1252. The bi-wall or its rooms on the east side were not fully exposed during excavation and no doorways were encountered that permitted obvious floor level access to the midden from the building. The midden accumulated over construction fill and contained some interspersed construction material. No archaeobotanical samples are analyzed for this deposit but its faunal content provides comparative material with the early faunal record of the west kiva (1502). East kiva trash consisted of remains more typical of the later faunal record of SCP: turkey, cottontail and squirrel bones. Two bones, a fragment of a femur and a phalanx, were identified as *Canis* (CCAC 2004: Cultural Deposits, Nonstructure 1506, Artifacts, Animal Bone Analysis Summary). No evidence of specialized bird use was identified here, in stark contrast to the west side refuse.

West kiva rooms: 1503, 1505/1525, 1508, 1509, 1513 and 1519/1527

The rooms noted here are aligned with the west half of the building. Assuming the importance of directional cues in Pueblo cosmology, I have identified these rooms as west-oriented. Following Ortman and Bradley's (2002) hypothesis that the peripheral rooms represent a metaphoric and physical pathway of travel into the more elaborated east kiva, the following information provides details of the west half of the building beginning in room 1509. This room is located on the southwest side of the building at the dividing wall between the two kivas forming the straight wall of the "D." Most rooms were only partially excavated. Study samples collected from west half excavation units include the plaza, room 1513 and room 1527.

Room 1509, bi-wall room with three entryways

Room 1509 had three entryways: one into the west kiva space, one into the room next door on the west side (unnumbered), and an unusual access through a crevice in the bedrock of the cliff-edge. Below are the kivas of blocks 600 and 900. If entry came from this cliff-edge side, access to the kiva space was offset and more to the west by way of a stone step. Only some pottery sherds were recovered in this location. As with most peripheral rooms a doorway was found on the west wall that allowed access into the unnumbered and unexcavated peripheral room to the west.

Canis latrans (coyote; 5 specimens), *Canis lupus* (wolf; 2 specimens) compared with 129 specimens of *Canis familiaris*, domesticated dog. Dogs were obviously consumed during the various occupations of Shields Pueblo through the Pueblo II and Pueblo III periods. An effigy described as a "dog's head" made of clay was found in a secondary refuse deposit in the east-central edge of Shields Pueblo block 1300, the midden (Nonstructure 1321), however, was used during late Pueblo II (A.D. 1020-1060)(Till 2015:609).

Room 1508, an over height room

Because the D-shaped building may have been two stories in height, access through hatchways is likely. Room 1508 was 2 metres in height and contained some pottery sherds. Two surfaces were identified in this room. Vegetal samples collected from a roof fall layer were identified as *Juniperus* and *Prunus/Rosa* charcoal and *Zea mays* cob fragments and segments. Only partially excavated, the room contained a niche.

Rooms 1503 and 1505/1525, west kiva doorway border rooms

The main entryway into the bi-wall rooms and the west kiva is situated between 1503 and two-storey 1505/1525 (room 1525 is the upper storey of room 1505). Pottery sherds were located in the excavated portion of room 1503. This tall, wide plaza entry doorway was made smaller over time. Some ground stone tools and general debris "churned by pothunters and animals" was encountered in the excavated portions of the curved rooms 1505 and 1525 that form the arc of the "D" (CCAC 2004: Rooms, Structure 1525). A later blocked doorway originally permitted access to an unexcavated room between rooms 1505/1525 and room 1513, the last room on the west side of the building.

Room 1513, room with green pigment, coloured plaster and* Canis *skeleton

Room 1513 is notable for its elaboration. Red plaster and whitewash tan plaster was found still adhering to some of the sandstone wall blocks. Green pigment was found in this room. A single almost complete canid skeleton was found in this room (Muir 1999:100). A small amount of secondary refuse was noted on the floor of room 1513. A broken up firepit was identified in a stratum of roof fall that appeared to come from the roof or secondary storey. Vegetal samples from wall and roof fall layers consisted of *Juniperus* and *Cercocarpus*-type (Rose family) charcoals. The firepit was located in the middle of these strata. A flotation sample yielded *Juniperus*, *Prunus/Rosa*-type charcoals and some charred cob segments. In the secondary refuse below these layers, numerous domesticated plant remains were identified from vegetal samples: *Cucurbita moschata* (butternut squash) seed, *Cucurbita*-type rinds and seeds and *Lagenaria* (gourd) rinds, some partially charred others uncharred testifying to the excellent preservation conditions at Sand Canyon Pueblo. An uncharred *Pinus* nutshell and *Zea mays* cob evidence was also identified. Charcoal remains consist of *Juniperus*, and *Pinus* (some uncharred), as well as a variety of more shrubby taxa: *Acer* (found previously only in the great kiva), *Amelanchier/Peraphyllum*, *Cercocarpus*, *Prunus/Rosa* and, tentatively identified *Fendlera* (fendlerbush). Tan and red plaster fragments and large amounts of green pigment were encountered in these strata. Originally a doorway provided access to room 1504 on the east half of the building that was later blocked. Room 1513 shares similarities with room 1510 on the east side of the building, found to have red and green pigment, and another almost complete canid skeleton. Green pigment is also recorded for room 1527 and noted for room 202 (block 200), green painted designs are documented for the kiva mural in the subterranean kiva of block 500 ("*tchamahia*" kiva 501).[80]

Room 1519/1527, west kiva two-storey corner room

This room fills the northern one-third of the inner space of the west portion of the inner "D" between kiva 1502 and a wall that provides separation from the kiva. Aligned with the wall that divides the building into roughly equal halves, access is difficult to discern as the area surrounding it was not fully excavated. The lower storey, room 1519, was approximately 1.35 m in height and contained refuse in the fill where clearly trash was dumped. A chipped stone tool was recovered in the fill. Vegetal samples from secondary refuse strata were identified as *Juniperus*, *Pinus*, *Artemisia tridentata*, *Chrysothamnus*, and *Purshia*-type charcoals. The room was not burned and the charcoals originated from elsewhere. A few *Zea mays* cob segments and a fragment were identified, all collected from above the floor surface. The second storey room, 1527, contained pottery, pottery sherds, a ground stone slab with a groove along its length, and a fragmented biface (a ground stone tool with flaking on both sides).

<u>East kiva rooms: 1504, 1507/1526, 1510, 1511, 1518, 1521 and 1523/1524</u>

The rooms noted above are those most aligned with the eastern half of the building. Findings here are reviewed as previously, following a route of travel through the bi-wall rooms on the east side of the

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[80] The colours green or blue/green/turquoise have cultural import for historic and contemporary groups in the American Southwest that surely grew out of ancient traditions. Examples of "green" rocks in archaeological sites include a single green shaped brick that stands in stark contrast to others in the outer walls at Aztec Ruins, the site dated to A.D. 1110-1275 (Lekson 1999:69)(personal observation, July 2009). I observed an abundance of minute fragments of turquoise green rock fragments in samples from SCP midden 1214. Recent CCAC excavators have noted fragments of green rock, aka "the green rock" in the area (Steve Copeland, personal communication, 2009). What the colour signifies in terms of Hopi symbolism is briefly outlined in Appendix B. A blue-green connection to the turquoise and blue macaws of Chaco Canyon is an inevitable leap here. Mathien (2001) notes the earliest use of turquoise in Chaco Canyon in A.D. 500s, making the argument that, over time increased production and turquoise manufacturing occurred at Chaco, and spread to other great houses dating from the A.D. 1100s. At Pueblo Bonito, mortuary evidence suggests that turquoise was associated with distinct groups of people. Fewkes (1896 in Pogue 1912) records the findings of turquoise ornaments and objects in Pueblo ruins in the Mesa Verde area, the jewelry similar to that worn by the women on the Hopi mesas, noting that the color was mostly a rich green and that turquoise matrix was also used in the production of objects and ornaments. The apparent "absence" of turquoise in archaeological sites may be the result of its beauty and cultural importance: Russell (1904-05:112 in Pogue 1912:463), re-iterates from a 1848 military report, of the common historic Pima and Maricopa practice of seeking out and searching ancient ruins after rainstorms for "trinkets of shell and a 'peculiar green stone' [turquoise]." In the rarity of turquoise at SCP, perhaps any stone of a green/blue hue might suffice since the colour is important for metaphoric characteristics much as maize (see Ford 1980). A single turquoise bead was recovered under plaza surfaces in front of the main doorway to the west side of the D-shaped building (nonstructure 1500), in the general vicinity of the dog burial. Mathien (2001:106) makes the observation little evidence exists for turquoise production in the A.D. 1200s. This may be the result of looting or more pressing concerns during occupation. A "green rock" may have a "borrowed" symbolic association.

D-shaped building. Study samples collected from the eastern half were collected from room 1507 and 1511.

Room 1504, over height room with small floor pit

Room 1504 is located directly to the east of room 1513. Room 1504's location in northeast arc of the bi-wall provided direct access into the space surrounding the east kiva. It appears to be a very tall one-storey room. Few artifacts were located on the floor and the absence of refuse in the fill suggested that the room was not used for a time. Along the north wall was a small pit. Later an ephemeral fire left a burned spot on the floor. At one time the room contained three doorways that provided mutual access between the peripheral rooms to the west (room 1513) and east (1512) as well as access to the east kiva (1501). All were later blocked. The room is distinguished by a single *Canis* sp. (dog/wolf/coyote) bone, a few large bird bones (larger than mallard), and some small mammals such as squirrel or of jackrabbit size. A variety of tools were encountered both in roof fall and on the floor.

Room 1512, the jumbled slab room

To the east and curved with the arc, is room 1512. Two blocked doorways were identified; one once provided access to room 1504, the other to a room to the south (1511). The room contained a small niche. Pottery sherds, a peckingstone and a beautiful and broken Mesa Verde Black-on-white bowl were found here (vessel 200)(CCAC 2004 Rooms, Structure 1512). The room appeared to have fallen into disuse. Some type of organic material was noted on the floor and natural sediment accumulated above it. Original photographs taken of the excavation show a number of large shaped and thin sandstone blocks resting on the floor (CCAC 2004; CCAC 2015a).

Room 1511, the Stipa/Hesperostipa comata room

Room 1511 to the south was found in a similar condition to that of room 1512, no artifacts on the floor, the doorway blocked. The deposit was thick with ash, charcoal and heavily disturbed by rodent burrowing. Partially charred *Juniperus* wood, *Juniperus* and Rosaceae charcoal and a partially charred *Cucurbita* seed and charred cob fragments were identified from wall fall vegetal and flotation samples representing refuse dumped onto unburned roof collapse. Early layers amongst roof fall debris yielded uncharred and charred *Juniperus*, *Pinus* and Rosaceae woods and charcoal. The same charcoal debris was found in the refuse fill below the roof fall. In my analysis (see following chapters), a rare *Stipa/Hesperostipa comata* (needle-and-thread grass) awn was found in this room.

Room 1507/1526, room with plant impressions and raven remains

Located to the south of room 1511 is room 1507, the lower room of a two-storey structure that shares its outer wall with midden 1506 on the east side of the building. The upper storey (1526) is inferred.

The south wall of this room terminates at the inner wall flat edge of the "D." No doorways were excavated and the room contains a niche on the southwest wall. Four distinct surfaces were identified in this room containing abundant evidence of plants. Vegetal samples from below the uppermost surface consisted of *Juniperus*, *Pinus*, charcoal and *Zea mays* cob segments. Located two strata below the second surface were layers containing impressions of twigs, grasses and shelled maize cobs that had disintegrated, all interspersed with small angular sandstone pieces. A vegetal sample collected here was identified as *Juniperus* charcoal. A capped surface is located below this layer. Strata underlying this surface consist of layers of adobe and impressions of sticks, grasses, maize cobs and a single *Cucurbita* seed. Vegetal samples collected from this layer were *Juniperus* and *Amelanchier/Peraphyllum* charcoal and a maize cob segment. Remains identified in a single flotation sample added *Amelancheir/*Peraphyllum, *Prunus/Rosa* and *Quercus* charcoal to the known plants associated with this room. Faunal remains include the ubiquitous large birds and cottontail rabbit, a single *Odocoileus* sp. (deer) and *Corvus Corax* (raven) bones were identified.

Room 1518, a re-used room

Partial excavation of the corner southeast room of the bi-wall (room 1518) exposed no features or doorways. Two prepared surfaces were identified but only roof debris and a few sherds were found on the latest floor. An ephemeral surface was noted over a thin layer of washed in sediments suggesting the room had been reused at some point.

Room 1510, room with red and green pigment

Room 1510, located between 1518 and the dividing wall between the two kivas, is the final "east half" room on the straight edge of the "D." Lacking any evidence of refuse in the fill, the room appeared to have fallen into disuse permanently. At one time, it may have had an upper storey. The room contained red and green pigment in the roof and wall fall, neither associated with plaster. Below layers of roof and wall fall excavators noted a thin layer of fine powdery silt loan that was "rich in decomposed organics." It covered the entire floor and may have come from the ceiling or room above. Vegetal samples from a roof fall and mixed refuse strata were identified as uncharred *Juniperus* and *Pinus* wood. Below the surface uppermost surface a vegetal sample was identified as containing *Juniperus*, *Pinus* and *Cercocarpus* charcoal. An almost complete dog skeleton was found in this room, similar to room 1513, located directly kitty corner in the northwestern section of the bi-wall (Muir 1999).

Room 1521, the northwest oriented kiva corner room

The east kiva has two kiva corner rooms, one very small shallow space in the northwest corner of the interior space around the kiva and between the bi-wall (room 1521). Only 45 cm in height, it was accessed through a pass-through. Animal burrowing in this space was found in association with uncharred *Pinus edulis* nutshells, an indication that perhaps the abundance of pine nutshells in the D-shaped building may be due to rodents. Scott and Aasen (1985) record charred and uncharred pine nutshells in block 100. A few pottery sherds were catalogued for room 1521.

Room 1523/1524, the southwest oriented kiva corner room and crawl space

The southwestern kiva corner room is two stories in height. The lower room (1524) is approximately 96 cm above the floor and has no hatchway and no access to the upper storey (1523). Abundant decomposed sticks and other material were encountered in the upper storey (1524) (CCAC 2004: Kiva corner rooms, structure 1524). Access to this room was through the south end of the ventilation tunnel. The upper room (1523) was a crawl space with no features, no hatchway and no access to the lower room. Some pottery sherds were found in the fill was noted.

The east kiva is distinguished by its elaboration and unusual bi-wall rooms. Remnants of wall decoration are evident in room 1513, a room closest to kiva 1502. Although the rooms appear to have fallen into disuse and doorways blocked, the abundance of organic material either stored or introduced at some point provides evidence of typical Pueblo III staples. None of the charcoals here included shrubby plant types such as *Artemisia tridentata* or *Chrysothamnus*, species that are prolific at the site today. Pollen samples from Shields Pueblo, approximately 10 km distant from the site dated circa A.D. 1280-1300, show a decline in these species, the differences inferred to reflect shifts in local vegetation tied to drought cycles (Adams 2015:156). These plants show up in latest context at Sand Canyon Pueblo. Using ethnographic sources, they were typical fuel woods, dried on roofs for easy access. The presence of these species in roof fall suggests a similar approach to fuel needs.

The units and features summarized here provide evidence of a continuity of plant use through time at Sand Canyon Pueblo. Typical fuel wood choices are juniper, pine and rose species with shrubs such as sagebrush and rabbitbrush less commonly identified. Domesticates such as maize and beans were present at the time of the final attack in kivas and in roof fall. Typical Pueblo III wild seeds—prickly pear cactus, common groundcherry, cheno-ams and purslane were present in the earliest and latest contexts. Unusual seeds, some found in caches include big sagebrush in block 100 and bitterbrush and penstemon in block 1200. Plants such as prickly pear, winged pigweed, and wolfberry are ethnographically associated with warrior themes, found in latest occupation contexts. The unusual collection of plants in block 100 such as bee plant, mallow, and blazingstar are known to be pharmacologically active. In the study that follows, I explore these connections and add additional plants to the record of Sand Canyon Pueblo.

Chapter summary

Of the fourteen architectural blocks identified for Sand Canyon Pueblo, nine are represented by study samples. Of these, the spatial contexts include outside the site-enclosing wall, kivas, rooms, and towers. Because of the brief span of the occupation and the limited excavations, some samples are ambiguous in temporal and depositional context. To compensate, I estimate Sand Canyon Pueblo time by using a decade/key event scheme for comparisons between samples. The information synthesized in this chapter provides baseline data and contextual information for the additional samples and volumes I examined. I approach the analysis of additional samples for SCP not for species "representativeness," but rather from the standpoint that more volume may produce more information and enhanced understanding of the site.

Chapter 8 Sand Canyon Pueblo study, part 1: bulk volume

Chapter overview

A standard measure for excavation, the one-litre flotation sample as an analytical unit may be insufficient for adequately representing the archaeobotanical content of bounded deposits at Sand Canyon Pueblo (SCP). To assess the effects of bulk volume, I analyzed additional samples from the site and compared the results to the known archaeobotanical record as published in 2007 (Adams and colleagues) and data documented in the Sand Canyon Pueblo and Multi-site Research databases (CCAC 2004; 2015a). I use two measures of assessment: a comparison of "species richness," an accounting of new genera, species, and parts in terms of numbers, and a comparison of estimated "interpretative richness," the possible inference value of the taxa recovered. Throughout this chapter I make reference to ethnographic sources to explore interpretative values.

Background

Archaeobotanical sampling strategies are designed prior to excavation based on knowledge of other sites and may or may not produce the results we anticipate. In the final analysis we rely on various measures to speculate on the cultural meaning of archaeobotanical data. Ubiquities, relative specimen abundances, and/or ratios of different types of plant remains are typically used to interpret the plant record. These are important measures but ones insufficient for developing or assessing a sampling strategy. By factoring in interpretative "values" of the material identified, the challenge of reasonably accounting for plant remains is tackled from the mindset of plausible inferences rather than species variety, thus capturing some essence of how people might have thought about and addressed the realities of their lives and economies. This approach permits speculation about the archaeobotanical signature these realities might produce, our contemporary signature constrained at the outset by debris, time and budget considerations. More than this, inferences realign the analysis by centering interpretative potential in historic ethnobotany.

Indigenous archaeologist, Sonia Atalay (2010:50) expresses it well when she writes, "regardless of where we conduct research, it is a privilege to study someone's past."[81] In this respect

[81] Often we are limited to generalizations of inferred "human usefulness" for the plant remains we identify. By this categorization the cosmological importance of a life lived is de-emphasized. The point of analysis is a speculation on "meanings" embedded in archaeological artifacts of all kinds. Some measure of this quality can be accomplished through the historic language used by descendant groups regarding their plant choices. Sekaquaptewa and Washburn (2009:196-197) recently wrote of archaeology, "one of the unfortunate results of the flurry of theoretical model building in the last several decades…has been a distancing of lived culture from

revisiting the histories of affiliated descendant groups provides alternative and deeper perspectives from which to view plant remains. Sampling methods are designed to respond to these pressures all the while attempting to address the concern for meaningful data.

As in the previous chapters, I use information from Adams et al. (2007), Kuckelman, ed. (2007), Kuckelman (2007a, 2007b), the Sand Canyon Pueblo database (CCAC 2004) and the Crow Canyon Archaeological Centre Research Database (CCAC 2015a) to compare basic counts of genera, species and unique plant parts and to synthesize and understand context (outlined and explored in chapters six and seven). Identification criteria conform to Adams and Murray (2004) and detailed in Appendix C. I assign interpretative values to identifications from both my analyses and previous analyses to provide a baseline for comparison. "Interpretative richness" reflects the qualities that archaeobotanists hope to achieve through sampling, qualities that typically have not been fully explored in contemporary sampling designs. This introduces inference value into the equation of how we quantify "adequacy." I hope to avoid simply a list of "useful" plants and reintroduce a small measure of respect for the complexity of "someone's past" to use Atalay's words by accounting for ethnobotanical and contextual values. To avoid, as much as possible, inadequate sampling that leads to limitations on deeper and more meaningful insights. By quantifying richness on two scales it is possible to see how data are lost and how quantification as a method can de-emphasize interpretation.

Scope of analysis

The question I pose for the bulk volume analysis is this: *Is a single one-litre flotation sample adequate enough as an analytical unit?* By assessing only single samples from different contexts, the single one litre sample in effect, becomes the "deposit." The question leads to the inevitable quandary of what constitutes "adequate." Did the general sampling process provide enough information to reasonably speculate on, and understand, the interrelationship of people with the plants they used?

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academic interpretations of it." They go on to acknowledge that, "this distancing is partially due to the failure to recognize and understand the prevailing metaphorical basis and modes in which these metaphors are expressed in Pueblo culture. In part, this is due to a lack of full linguistic competence on the part of the anthropologists studying these peoples. If a people's culture is embedded in their language, how little we will understand them if we are not conversant with the nuances and special meanings about life and belief that are internalized in their daily and ritual languages." Whiteley (1998:111-113) describes the Hopi "poetics of naming" as "more compact than haiku" in which "the acuteness of Hopi perceptual distinctions it reveals...[is] a quality echoed in the strong visual emphasis of many name-images" (112-113). While I make no attempt to fully explore the linguistics, the exercise of including language can provide an additional line of evidence to support the importance of certain plants in the historic period. Out of mindfulness for language and metaphor, I include botanical terminology of the Hopi and Zuni as noted in ethnographic sources keeping in mind Seaman's (1993:xxiii) caution: "[w]ord lists are now considered of much less importance than the unique ways in which different peoples string together words into sentences, paragraphs, and longer utterances." My study is limited to "word lists" to some extent and only when historical terminology is available. To evaluate a plant species as simply "food" categorized by "domestication" or "wildness" misses the complexity of how traditional people viewed their plant categories.

The answer lies in the interpretative potential of individual taxon and the spatial and temporal context of the individual deposit. The evaluation is based not simply on a defined volume (the one-litre "bulk" sample) but on the depth of the original question, adding:

> *Does additional volume enhance not just our ability to recover remains but to interpret the record appropriate to the realities of the occupation within a reasonable standard of acceptable doubt?*

In this study, Sand Canyon Pueblo is a test case. Here, through examination and reexamination, these questions can be explored through Sand Canyon Pueblo's existing and emerging data. All samples in this analysis have been subsampled using the species-area curve (SAC) approach and as a result additional material is still available for analysis. The underlying question aims to explore whether additional bulk (subsampled) volumes can make up for presumed losses imposed by subsampling the smaller light fraction screen portions. SAC subsampling is discontinued based on the noncapture of new genera, species or parts based on only clearly identified botanical morphology, that is, enough morphological traits must be observable to confidently anchor identification. Interpretation of the data follows only in the later analytical stages. These are materials that are difficult to characterize and do not propel additional subsampling and represent "worked" remains such as the grinding of seeds or maize kernels. If not describable using clearly defined morphological terms, ground remains are effectively lost in the collection of data, relegated to "unknown tissues" although the analyst may strongly suspect the source. As is the case for identified "species," some of these categories may have little value for increased sampling effort; others by virtue of their unexpectedness, temporal/spatial placement, ecological and anthropological potential as evidence of cultural phenomena have great value for inferences and warrant increased sampling effort.

Fragmentation clearly plays an important role in the interpretative analysis. Sutton and Reinhard (1995) have statistically demonstrated two seasonally specific Pueblo III cuisines: pre- and post-maize harvest based on coprolite evidence from multiple sites. To understand the final days and weeks of occupancy at Sand Canyon Pueblo, seasonality is an important component to speculate on the scheduling of activities in what was a community that relied on seasonally available plants. Ground maize is pre-harvest, whole kernel maize is post-harvest. The signature of each could be visible if fragmentation is considered a separate analytical category that propels additional sampling effort. Methodologically, an underlying complication of analysis includes the cultural importance and later analytical category of "absence" and what this could signify. If we assume that a lack of identifiable plant remains puts an end to sampling, we may be missing the point. "Absence," as any assessment of resource stress confirms, is a loaded designation. Without irrefutable proof that something is indeed absent as opposed to "not observed," how then can we legitimately explore the questions of "*why*?"

Ford (1985:412) cautions, "[a]nthropological ethnobotany examines plants embedded in a cultural matrix and can answer special questions that botanists have neglected to ask." Finding ways to assess sampling for the capture of cultural content must include a seasonal component and cultural scheduling. Both are important contributors to how we classify and consider samples to be "representative." Investigations of plant structure and biology are indicators of the cultural and ecological environments that include seasonal scheduling, nutrient or medicinal potential, esthetics and other possibilities. People interact with plants within a cultural milieu, a "context" writ large: the abiding and interconnected association of people to the living world as evidenced in the preserved remains.[82] In order to build some sense of this lived experience back in to the equation of sample analysis, I offer assessments of inference potential that conform to standard practice, are tailored to fit the archaeobotanical goals of the SCP investigation and add cultural value. Factoring in "value" is useful for assessing sampling strategies after the fact, but also has potentially positive impacts in the in the funding stages prior to excavation. The development of a *relevé*-style outline of plant cover and expectations that make use of contemporary indigenous, ethnographic, ecological, and contextual knowledge in the initial development of a project may help tailor research questions more finely, garner additional support and be more responsive to site and deposit-specific realities, serving the record, the discipline and descendants more responsively.

Local knowledge as local theory: an interpretative value approach

Estimating archaeobotanical potential is certainly not a new idea. Adams (1988) provides a predictive model for archaeobotanical expectations based on wetland habitats in Arizona using ethnographic source material. Wollstonecroft (2000) uses a similar approach on the Northwest Coast of British Columbia. Both incorporate indigenous knowledge as a fundamental value, privileging historic and contemporary *local* perspectives in the process of generating meaningful interpretation. The analysis I present here privileges the same philosophy. In the beginning phases, it is a conversation of sorts about artifacts and ecofacts within the confines of specific interpretative categories outlined in the archaeobotanical analysis of Sand Canyon Pueblo (Adams et al. 2007): the food, fuel and other plausible cultural categories. This requires exploration of what is indeed a mosaic of content and context. Investigation logically begins in the "local." Those closest to the past, allied to it, operating in relationship with it, and echoing its continuities provide local knowledge that can be "tested"

[82] Ridington (1982:473) makes the following observations that "human experience is a life-sustaining network of relationships between all components of a sentient world...as a mosaic of passages and interactions...against a backdrop of a terrain...[and] continually in process..."

against the material culture of archaeological sites. I examine the plant record, the artifacts, and archaeological arrangements of Sand Canyon Pueblo to explore the cultural content through the lens of Whiteley's (1998:13; emphasis in original) "local knowledge as local *theory*," described as follows:

> Ethnocriticism seeks "to alter or ambiguate Western narrative and explanatory categories...." Putting this into practice requires: ...real engagement with the epistemological and explanatory categories of Others, most particularly as these animate and impel Other narratives. The necessary sorts of movement, therefore, are not only those between dominant western paradigms but also those between western paradigms and the as-yet-to-be-named paradigms of the Rest (1998:113).
>
> ...The play rests upon certain epistemological convictions, which, were it not for the madness of the postmodern moment, seem simple truisms that would be needless to state. The first is an existential realism about human social life. The second is a belief that language can indeed describe experience, both individual and collective....Third, cultural ideas are intersubjective in Wittgenstein's sense and they get expressed and acted upon in objectively describable social practices.

Furthermore,

> While there may be "people without culture" and certainly there are "people between cultures (Rosaldo 1989), the general idea of, say, Hopi culture, seems to correspond well with an identifiable complex of ideas and practices with persistent cores of meaning – amidst transformations, reproductions, and changes – that a particular group of people claims for its own, and associates with a distinctive language, form of social dwelling, history, and territory. While diaspora, transnationalism, and deterritorialization militate against a holist view of culture, this should not require that the model, as paradigmatic, be jettisoned, rather than qualified and resituated (Whitely 1998:13-15).

The distinctions echoed in historic and contemporary reiterations of durable themes in Pueblo life, contain "cores of meaning" that are clearly evident in the art, artifacts, architecture, and archaeobotany of Sand Canyon Pueblo with elements from Chaco Canyon enduring into the present day. Martindale (2006:165) notes that,

> first, the oral record complements archaeological reconstructions of the past by providing cultural and historic content for Indigenous history, which is the goal of much archaeological work. Second, oral records also present historic data from an Indigenous perspective, a view that represents a useful counterpoint to the dominance of European perspectives.

That said, the whole story is never told but "cores of meaning" are understandable as Whiteley makes clear through linguistic analysis (1998). Even when Indigenous information is thousands of years old (Martindale 2006:165), I will demonstrate that ideas and practice are persistent. To quantify additional information from these sources I am creating a kind of *value* "database" along the lines of

Bakewell's (2011) "shocks of familiarity" between the artifact, the ethnobotanical, and the ethnographic. Whether these strike a chord for others requires some consideration of whether the descendants wish us, as "other," to pursue it further through acknowledgement, confirmations, or alternatives. Regardless, the language around archaeology and archaeobotany requires a new sensitivity for its inadequacy in securing evidence using only scientific approaches. Social science on the other hand, can capture hints of deeper human categories through an analysis of the entire content of the site and its affiliated "others." As a method of analysis, the true value of local theory, in my view, is that it sheds light on archaeology, a type of "people without [apparent] culture," that I more accurately describe as, "dominant culture, momentarily suspended, and in awe." It is easy to forget our own biases and to become so fully engaged that it is possible to disappear into the liminality of archaeology on some level. Certainly, the continued evaluation of method demonstrates how the creation of "data" from the collection of "taxa" can be expanded to embrace an *ethno*critical approach to what we are doing, why we are doing it, and how we can do it better. We are, perhaps, not "the Other," but "the Rest" in this shifting and transformative world of "research." The last thing we want is to undermine evidence and unwittingly diminish descendant perspectives of what are fundamentally *their* artifacts and *their* history. As Dods (personal communication 2015) notes, there are an almost infinite number of logically possible worlds to consider.

Archaeologists and anthropologists (and frankly any research seen as a "scientific" or articulated as "Western scientific" endeavors) can be, and often are, viewed as reflections of colonialist and imperialist disrespect for others and "other" kinds of knowledge (Watkins 2005). Also seen as overwhelmingly reductive, the Optics of Archaeology (capitalized) appears as an arrogant claiming of someone else's past because archaeologists—often the nonlocal, nonindigenous, and seemingly empathetically disconnected—interpret it. In practice, all things "anthropological" are viewed with suspicion by those who are not anthropologists or archaeologists, a phenomenon not entirely limited to indigenous peoples who have more experience and right to make such claims. Whitely reminds that the purpose of ethnography (and I add, archaeology) is "origination," finding the true meaning from the perspective of the originator—to empathize and understand. The process sheds light on a world of historic and contemporary groups and our perceptions of our own and the world of the artifact and artifact "maker," who is, in fact, a *local* ancestor. To explore, in his words, "how Hopi [Zuni, Pueblo] perspectives, in so far as I [we] understand them, construct, create, and constrain social life…" (1998:13). Archaeology, like ethnography, desires "to engage [local] analytical perspectives with an aim that is both restorative and corrective," (13; emphasis in original), perhaps taking some of the sting out of our shared and tragic history.

Wobst (2010:18) casts archaeology as "archaeologies" where acknowledgement of intangibles is crucial - "different people have different ways of and logics for interacting with their material world and the human artifacts around them…we need to be sensitive to the different ways in which people in a given society relate to their artifacts, and we need to get a much sharper sense of how materiality varies and changes across space, time, and perceived social boundaries." Atalay's caution of "someone's past" incorporates this reality. The reclamation of the Zuni *Ahayu:da* also makes clear an unexpected perspective on value and "sensitivity" (Ferguson et al. 1996). The idea that the artifacts we find valuable in archaeology may have been the objects with little sensitivity beyond their pragmatics of use is discouraging particularly when considering that the culturally valuable, more sensitive and meaningful are designed to disappear into the transcendental and remain hidden from direct view. A glimpse into the historic records of the "ethnographic past," serves to remind us of our shared experience through the discomfort that comes with re-reading some shameful language and methods of our shared past. There exists a real potential for more empathetic and sensitive approaches in this harsh reality. At minimum, these records serve as experiences that capture place and time where both can claim the unfortunate label of "Other," hinting at how the process could have been for Puebloans and ethnographers, exposed as they were to a world not "known," one that was foreign, intimidating, and powerful in unknown and dangerous ways. I apply historical information within the categories defined by the original goals of archaeobotanical analysis of SCP in an effort to understand the contextual nature of the evidence (Table 8.1).

Table 8.1 Inference values: simplified categories of interpretive potential for SCP samples (abbreviations noted in Appendix E tables).

Category	Botanical categories and basic inference types	Abbreviated form
Foods (F)	Domesticates (reproductive parts of *Zea mays*, *Phaseolus*, *Cucurbita* …)(D)	FD
	Wild resources, weedy types (reproductive parts such as seeds, fruits, etc.)(W)	FW
	Wild resources, nonweedy types (N)(reproductive parts such as seeds, fruits, etc.)(N)	FN
	Wild resources, other (beverage, undocumented, unknown, presumed food)(reproductive and other parts suggestive of this category)(N)	FO
Fuels (FL)	Non-shrubby growth habit (wood, charcoal)(N)	FLN
	Shrubby growth habit (wood, charcoal, twigs, fragments)(S)	FLS
	Zea mays cob remains (parts lacking apparent food value such as cobs without kernels, cupules, glumes)(Z)	FLZ
	Tinder-like remains: bark scales, leaves, needles, twigs (shrubby woods?)(T). These materials are also ethnomedicines and although categorized here under tinder as reflected in the original analysis of these specimen types, I present an alternative explanation as "medicine" in later chapters.	FLT

continued…

Table 8.1 Inference values: simplified categories of interpretive potential for SCP samples (abbreviations noted in Appendix E tables) continued.

Category	Botanical categories and basic inference types	Abbreviated form
Other (O)	Ecological indicators (seasonality,[a] geographic locale…)(E)	OE
	Unknown (potential use as medicine, beverage, dye based on ethnographic, biological properties, etc. (U)	OU
	Worked (shows signs of human modification or processing)(W)	OW

Notes:
[a] Seasonality/phenology could be applied to many of the food resource categories but is suggested in cases that has the potential to enhance interpretation of a feature or deposit. I do not include seasonality for domesticates as a value category in table format but refer to harvest times in discussion.

I assign inference values within these categories to reinforce the importance of archaeobotany as an interpretative study of a relationship, not a collection of data by accounting for “data” and “values.” This allows comparisons between the known record and new information to suggest whether the current sampling approach works effectively based on the questions posed. The deeper analysis of interpretative potential is summarized in chapter nine. All data are summarized by individual sample in Appendix E indicating the interpretative category I assigned.

Rather than assume that sampling strategies are designed to capture commonly occurring remains and occasionally, the most rare (the experimental data confirm that common and rare are problematic assessments), I focus on the single deposit and single sample to explore what new information might mean for a cultural space, the important individual places where people gathered and worked with plants. I take Ford’s (1988:216) caution regarding statistical outliers and “rare” as eminently wise: “rare little things are often significant for cultural interpretation. Their low probability of occurrence may highlight their actual importance.”

Methods and materials

All samples were subjected to the SAC approach or an adapted version (detailed provided) and any reference to subsampling should assume SAC subsampling standards. As laid out in Adams (2004), the application of the approach is triggered by a total light fraction volume of 50 ml. Subsampling is then applied to the three smallest screen sizes (1.4 mm, .71mm and .25 mm) regardless of the volumes retained in these portions. In some cases I chose to subsample using the SAC approach when the total light fraction volume was less than the 50 ml. This decision was based on excessive quantity of microscopic sediments retained and is consistent with some of the previously analyzed samples. Subsampling in this way reflects the persistent problem of debris in light fraction, a problem I return to in the discussion chapter (chapter ten). It is important to consider how the triggering volume, manageable in certain circumstances, becomes unmanageable in others. All volume amounts are considered approximations.

Sample selection

I chose twenty (*N* = 20) previously unexamined samples based on my best estimate for temporal context as outlined in chapter five. Ten (*n* = 10) samples were excavated from primary refuse contexts; ten (*n* = 10) were from secondary refuse contexts (chapter five, Table 5.2). All effort was made to match samples for reasonable comparison. Primary refuse samples are documented as comparisons: two burned spot, three firepit and five hearth comparisons. Secondary refuse is documented similarly: four midden comparisons and six trash accumulations not specifically designated as “midden.” Comparison samples (referred to as either “CV” samples, meaning “comparison volume” or “volume 1” reflecting original analyses) are those samples originally examined for the final report. There are 25 comparison samples (CV1-CV25). New samples, FV (flotation volume) are labeled FV1-FV20 and were examined by me in 2009. Often the entire deposit was not fully excavated and therefore no assessment of the “representativeness” for a deposit can be made, although new data may provide additional information. The term “species” used in this analysis incorporates family, genera and species identities and is used as a convenience in discussion.

All remains, botanical and otherwise that could be identified or described are documented for the “new” samples, the ones I examined. As part of a wider view of flotation sample evaluation, this additional information is helpful in considering the kind of materials associated with flotation samples. Increased quantities of uncharred plant materials can suggest a deposit is not wholly ancient in origin due to the mixing of material (modern into ancient) or, particularly in the case of uncharred domesticates or other clearly ancient remains, provide evidence of an undisturbed and/or well preserved deposit. Charred and uncharred evidence of disturbance by insects or animals offers another line of explanation for the *absence* of edible/food remains. Particular types of insect remains may suggest ecological conditions or season of activity. Adams’ (1984) study of termite fecal pellets found in association with charred wood remains has offered a direct line of evidence to suggest the re-use of old wood such as construction beams in latest occupation fires at SCP, linking the dismantlement of older structures to a secondary use as fuel sources. These destructive little creatures may also explain some of the differences in tree-ring cutting dates, termite infestation causing demand for new beams.

Flotation samples provide much more than just archaeobotanical data and for that reason, and taking heed to Vorsila Boher’s advice (1986:33), I attempt a comprehensive survey of new samples to try to document both cultural and noncultural evidence.

Quantification of results

Quantifying results of new analyses is biased. As Drennan (1996:86) cautions, the "concept of *representativeness* is a slippery one" and one that is subjectively biased depending on how analytical categories are defined and assessed. Whether you are a lumper—someone who focuses on the similarities of particular categories of things, or a splitter—someone who focuses on the differences between things, there are inherent problems in the process. A good example is the problem of accounting for pine wood. Ancient Puebloans used different varieties of pine, the most obvious species in the Sand Canyon region are *Pinus edulis* (pinyon pine) and *Pinus ponderosa* (Ponderosa pine). Each wood type shares morphological similarities and differences and are identified microscopically on the basis of their resin canals. Pinyon pine resin canals are morphologically distinctive and hard to miss. No pinyon pine charcoal was identified in previous analyses at Sand Canyon and as a result the identification of charcoal as pine may reflect species other than pinyon. Pine and pinyon however, are generally lumped together as one taxonomic category reflecting the human use of pine wood. In this analysis, I split pine into two taxonomic categories: *Pinus edulis* and *Pinus* sp. to account for pinyon pine and "not" pinyon pine. Although it is possible that fragments of pinyon charcoal were too small to contain an identifiable resin canal, the majority of pine charcoal I identified is overwhelmingly pinyon. Subsampling for charcoal in the largest light fraction screen sizes produces specimens of larger remains and larger pieces of charcoal that are likely to contain these structures. By splitting pine to account for pinyon and not-pinyon, it is possible to shed some light on specific uses of varieties of pine. For inference potential, the growth patterns, reproductive and subsistence potential of the two species need to be considered. Ponderosa and lodgepole pines are effective choices for large beams being tall and straight, pinyon is most notable for highly prized edible pine nuts. Dead and dry pine wood makes excellent tinder. In some cases the distinctions are important, in others cases the information yields little new information. In the results to follow interpretative values/inference potentials are estimations and inferences of potentials, a simplistic view of the process of "taxa" turned "data."

Of the twenty new samples assessed in this study, fourteen provided information that enhanced the interpretation of their associated deposits. Six samples contributed no new cultural or ecological insights based on the categories of analysis and my subjective opinions supported by ethnographic analogy. Of those samples, one originated from a firepit, three from hearths, one sample from a midden, and one from a trash accumulation (secondary refuse unspecified). Caution is required, however when considering how representative these samples are. The species-area curve subsampling approach was applied to the smallest screen sizes (.71 mm and .25 mm) regardless of the volume of light fraction retained after flotation in most cases. Although I examined the 1.4 mm portions without subsampling with the exception of midden 1214 (FV14 sample), this size grade of remains may not capture the more minute specimens that are expected in the smallest light fraction screens. All data are tabulated by individual sample comparison in Appendix E. Data are compiled by feature type in Appendix F.

Results—primary refuse

Burned spots

I examined two new flotation samples (FV1 and FV2) collected from burned spots and compare my findings to the plants identified from previously examined samples from similar deposits. Due to unclear depositional sequences, this analysis focuses simply on richness in terms of the number of flotation samples/volumes analyzed for burned spots and the inference potential of the taxa recovered. Burned spot features are interpreted to reflect single burn events the characteristics of which suggest use as campfires, some, at least based on the plant remains recovered, were used for cooking (Adams et al. 2007:para. 52). All burned spots at SCP are not formally constructed but appear to be expedient fires that suggest the need for light, heat, and/or cooking (CCAC 2004, Cultural Deposits, Arbitrary Unit 1).

Comparison 1: burned spots, arbitrary unit 1, block 100

"New" flotation sample, FV1 (Flotation Volume 1) was recovered from one of seven burned spots in this 2-x-2 m probability sampling unit located outside the site-enclosing wall near the D-shaped tower 101 in block 100 (CCAC 2004: Cultural Deposits, Arbitrary Unit 1). The unit follows the outside contours of the wall and could be associated with the activities in block 100. The vertical provenience of the burned spot and others in the vicinity is unclear. They are described as being part of surface 1, a series of cultural and natural sediments consisting of slope wash and deliberately placed construction sediment.[83] No dates are available for these surfaces. Because of the scarcity of volume associated with burned spot samples generally, FV1 is compared to three previously examined samples from three different burned spots in this unit to explore the nature of plant use in and around burned spots as a type of thermal feature used at SCP. The burned spot for this analysis (feature 1) is described as an ash mound on an oxidized surface created by what was interpreted as a substantial or intense fire. Irregular in shape, the measurements are noted to be incomplete at 46 cm in length, 36 cm in width,

[83] The location of the burned spots is detailed on Map 4310: Site 5MT765 Arbitrary Unit 1, 997N 1016E, Features 1-7 (Burned Spots) made available courtesy of Crow Canyon Archaeological Center (CCAC 2004). http://www.crowcanyon.org/ResearchReports/dbw/dbw_MapZoom.asp?FileName=e:\editor\maps\5MT765\Map4310.tif&Zoom=25&Site=5MT765&MapNum=4310&SUNum=1&SUTyp=Arbitrary+Unit&SUDesc=multiple+study+unit+types&StartingSUTypePage=Deposits_Page&Crit=Cultural+Deposits&RequestPage=Chooser_Page&RequestPage=SelectSU_Page&RequestPage=Deposits_Page&RequestPage=MapList_Page.

and 10 cm in depth. It appears that only half of the feature was excavated (CCAC 2004: Cultural Deposits, Arbitrary Unit 1). I compare my findings to the remains identified from three samples collected from three separate and shallower burned spot features (excavation features 2, 5 and 7) from this unit, relabeled here as CV1a, CV1b, and CV1c (Comparison Volumes 1a-c). Feature 2 (sample CV1a) is described as an expedient fire burned directly on a surface and measured 60 cm in length, 46 cm in width and 3 cm in depth. Feature 5 (sample CV1b) is recorded as 76 cm in length, 53 cm in width, and 4 cm in depth. This feature was not fully excavated. Feature 7 (sample CV1c) was 36 cm in length, 30 cm in width and 5 cm in depth and noted as containing abundant charcoal. Although the surfaces are problematic, the location and ephemeral nature of these fires outside the wall and near the tower may provide interpretative value when considering plant content in this location.

Prior to processing, sample FV1 measured 900 ml and is presumed to represent a reasonable estimate of the entire contents of the feature as no additional samples were collected. After processing, the total light fraction volume was approximately 47.25 ml. Due to the abundance of retained sediment in the smallest particle sizes, I subsampled the .71 and .25 mm screens examining 37.6 ml in total. Comparison samples CV1a, CV1b, and CV1c (CCAC features 2, 5, 7, respectively, associated PD/FS numbers: 729/1, 732/1, 737/1) yielded total light fraction amounts of, 30 ml, 50 ml, and 50 ml respectively. The total pre-flotation volumes for these samples are not available. Pre-flotation volumes for two other unexamined burned spot samples not used here but collected in close proximity on the same use surface measured 500 ml and 330 ml pre-float suggesting that sediment volumes for the comparison samples could be low also. Remains identified are recorded cumulatively as “volume 1,” and represent the known population of burned spots in this unit.

Original findings: CV1a, CV1b and CV1c (“volume 1”)

The combined taxa recorded for these samples/volume 1 consist of seven botanical, and one nonbotanical taxon. These are: *Juniperus* (juniper), *Pinus* (pine), *Amelanchier/Peraphyllum* (serviceberry/peraphyllum), *Artemisia tridentata* (big sagebrush), *Purshia* (cliffrose/bitterbrush) charcoal. Other specimens include *Zea mays* (maize) and cheno-am (*Chenopodium/Amaranthus*-type or goosefoot/pigweed). Fuel materials or tinder can be inferred from evidence of *Pinus* bark scales and the remains of *Amelanchier/Peraphyllum*, *Artemisia tridentata*, and *Purshia*-type shrubs. A *zea mays* cupule (the durable pockets that hold two kernels attached to a cob) is typically interpreted to represent the burning of cobs as a fuel unless otherwise indicated (Rainey and Adams 2004). A single *Amelanchier/Peraphyllum* pome may be the result of food use, overwintering fruit on fuel/tinder material, or provides clues as to seasonality of use (mature fruits are available in the Sand Canyon area around August to October [Adams 1993b:8]). The presence of cheno-am may signal the cooking or processing of *Chenopodium* or *Amaranthus* plants. A charred termite fecal pellet suggests the burning termite-infested wood, possibly scavenged from abandoned buildings (Adams 1984; Adams et al. 2007:para. 14, 70).

New findings: FV1

The "new" sample yielded two new genera not previously accounted for in comparison samples: *Cercocarpus* (mountain mahogany) charcoal ("absent" from the eight burned spot samples evaluated for SCP) and *Opuntia* (prickly pear) cactus seeds, limited to one sample in the previous analysis. All pine charcoal in this sample is *Pinus edulis* (pinyon pine). A new "part," a *Zea mays* kernel, hints at the consumption of maize. Plant and other remains documented for these and comparison samples are listed in Table E.1 (Appendix E), inference potential is suggested in Table 8.2.

Table 8.2 Suggested inference potential: burned spot comparison 1 (charred remains unless otherwise specified).

Interpretive category	"Volume 1" samples (CV1a)	(CV1b)	(CV1c)	New volume (FV1)	New taxa[a]
Foods					
Domesticates (FD)	-	-	-	*Zea mays*	*Zea mays*
Wild resources, weedy (FW)	-	-	Cheno-am	Cheno-am	-
Wild resources, nonweedy (FN)	-	-	-	*Opuntia*	*Opuntia*
Wild resources, other (FO)	*Amel/Pera.*[b]	-	-	-	-
Fuels					
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	*Pinus*	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Amel/Pera.*	-	*Amel./Pera.*[b]	*Amel./Pera.*[b]	-
	-	*A. tridentata*[c]	-	*A. tridentata*[c]	-
	-		-	-	-
	-	*Purshia*	-	*Cercocarpus*	*Cercocarpus*
		-			
Zea mays cob remains (FLZ)	-	-	*Zea mays*	-	-
Tinder types (FLT)	*Pinus*	*Pinus*	*Pinus*	*Pinus*	-
Other					
Other, ecological (OE)	*Amel/Pera.*	-	-	-	-
[seasonality]	pome[fall][bd]				-
	-	-	Cheno-am	Cheno-am	-
	-	-	[summer]	[summer]	-
	-		-	*Opuntia*[fall?][d]	*Opuntia* [fall?][d]
			Termite	-	-
			(uncharred)		Continued…
Other, unknown (OU)	-	-	-	-	-
Other, worked (OW)	-	-	-	-	-
Species (species/genera) count (combined total CV1)			**8**	**8**	**5**
Inferred interpretative values			**12**	**11**	**5**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

[b] *Amelanchier/Peraphyllum*-type. Both wood and a pome/fruit were recovered.

[c] *Artemisia tridentata*-type.

[d] Clear seasonality is ambiguous for these taxa. For example, *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. The presence of an *Amelanchier/Peraphyllum* pome may reflect persistent or overwintering fruit.

The content of the original samples provide a combined count of eight species (defined as genera/species/parts) including evidence of termite activity. A breakdown by interpretive categories suggest these remains account for twelve inferences of use from maize cobs as fuel to the burning of specific shrubs for fuel and tinder, some of which may suggest ecological or other information. The identified content of sample CV1c suggests the preparation of food. The additional sample (FV1) provides a richness count of eight species, five are new to these features. *Pinus edulis* is considered new information vs. the original identification of pine (nonspecific). In tallying interpretative values *Pinus* tinder type remains are considered new information for a total count of eleven values; six are new for this deposit. The interpretative potential of the taxa recovered in the new sample provide additional insights. The presence of cheno-am and *Opuntia* in an ephemeral fire outside the site-enclosing wall reflects something of typical Pueblo III diet (Reinhard 2006; Sutton and Reinhard 1995) and conforms to documented Puebloan meals in the historic period. Two historic methods for cooking corn might explain "absence" of corn in archaeological deposits: the Zuni toasted maize kernels while still on the ear or parched them individually off the ear. This was accomplished by either "burial and constant stirring in hot ashes," or by placing them in a pot of clean dry sand and stirring constantly with a "sprig of hardwood" (Cushing 1920:265-266). These methods would explain how individual kernels might come to be found in fires and recovered in flotation samples. It is less likely that kernels would become detached from the cob due to the burning of cobs as a fuel source. The same considerations apply to recovered cheno-am seeds. Some traditional uses include a Zuni recipe with mythological connections. Historically, Zuni *ᵗkia'tsanna*, meaning "small seeds" and identified as narrow-leaved lambsquarters (*Chenopodium leptophyllum* [Moq.] Nutt.) was mixed with a seed identified by the same name and documented as *Artemisia wrightii* Gray/now *Artemisia carruthii* Alph.Wood ex Carruth. [Carruth's sagewort](Stevenson 1915:66). Both species were traditionally ground with maize. The original *ᵗkia'tsanna* recipe of 'small seeds without corn meal' was "the first meal," given to the Zuni when they first emerged into this world, a time before they were gifted corn (66). Another plant associated with ground corn is *Opuntia.* Boiled cornmeal bread and the cooked fruits of Grizzlybear prickly pear cactus (*Opuntia erinacea* var. *hystricina* [Englem. & Bigelo] L. Benson) is a Hopi recipe (Moerman 1998:366). Cushing (1920:293, 587-600) describes a typical traveller's campfire meal for the Zuni: a bag of *tchu'-k'i-na-o-we*, dried *he'we* (*piki* or traditional wafer bread), salt, red pepper, and tobacco. *Tchu'-k'i-na-o-we*, a "favourite lunch material" (541) is translated as *tchu'-k'i-na* meaning "moistening flour" made from boiled white or yellow corn, *o-we* meaning "reduced to meal"(294):

> Of all substances known to the Zuñis, however, none approach in nutritive quality the *tchu'-k'i-na-o-we*, or "moistening flour." White or yellow corn is boiled with cob-

> ashes until the hull may be removed. It is then dried a day or two and well toasted in the parching pot, ground to a coarse samp, toasted again, ground to very fine flour, and once more toasted, then carefully sifted. Thus manipulated, what with waste and excessive reduction, a bushel of corn makes but a few quarts of flour. A single teaspoonful of this powder when stirred into a pint of water, will make a tolerably thick batter of it; in which condition it is drank, a few sips sufficing to satisfy the most hungry appetite. When combined with meat-meal, or jerked venison toasted and well ground up with red pepper and salt, it embraces all the elements necessary for man's sustenance...it may be preserved year in and out, is ever ready for consumption without the intervention of fire, and may be transported in small compass yet in sufficient quantity for a long campaign.
>
> Many a time have I subsisted alone on this meal and the game I shot, nor did I ever long for other foods the while. Tracts of barren country otherwise impassable, are made, by this food, the easiest routes of traders; and in times of war when a fire, however slight, might doom the party who kindled its flames, it becomes absolutely indispensable (Cushing 1920: 341-343).

As noted in chapter six, Sutton and Reinhard (1995) found that milled and whole kernel maize were "mutually exclusive" as dietary items in Pueblo III coprolites and interpreted to represent two very different consumption conditions: stored and ground sources when fresh maize was not available and kernels and cob evidence when harvest occurred (746). Significance testing confirmed that milled maize was found in association with milled or whole chenopods and/or amaranths or other small seeds. A trivet stone in one of the seven burned spots and a mano in the unit suggest that food processing occurred outside the site-enclosing wall in the vicinity of the tower in bock 100, even if only as a temporary processing locale.

Inferences of diet: Ancestral Puebloan coprolite evidence

Reinhard (2006:257) makes the following argument for diet breadth in Ancient Puebloan cuisine based on coprolite evidence:

> In general, the Ancestral Pueblo diet was the culmination of a long period of victual tradition that began around 9,000 years ago, when people on the Colorado Plateau gave up hunting big animals [the North American megafauna of 10,000 years ago] and started collecting plants and hunting smaller animals. Prickly pear cactus, yucca, grain from dropseed grass, seeds from goosefoot and foods from 15 other wild plants dominated pre-Ancestral Pueblo life. One of the truly interesting dietary patterns that emerged in the early time and continued through the Ancestral Pueblo culture was the consumption of pollen-rich foods. Cactus and yucca buds and other flowers were the sources of this pollen. Rabbit viscera probably provided a source of fungal spores of the genus *Endogane*, [84] although I doubt that these people knew they were eating the spores when they ate the rabbits…Prey for the pre-Ancestral Pueblo people included small animals such as rabbits, lizards, mice and insects. In fact, most pre-Ancestral

[84] *Endogane* is a fungus that grows on the roots of grasses and has been found in Archaic (pre-Basketmaker) coprolites. Eaten by rabbits, the presence of these spores in human coprolites is linked to the consumption of rabbit viscera (Reinhard 2000:130).

> Pueblo coprolites include the remains of small animals. My analysis of these remains shows that small animals, especially rabbits and mice, were a major source of protein in summer and winter, good times and bad. The Ancestral Pueblo diet *per se* descended from this hunter-gatherer tradition. Coprolite analysis shows that they were largely vegetarian, and plant foods of some sort are present in every Ancestral Pueblo coprolite I have analyzed. But these later people also expanded on their predecessor's cuisine. They cultivated maize, squash and eventually beans. Yet they continued to collect a wide diversity of wild plants. They actually ate more species of wild plants—more than 50—than their ancestors who were totally dependent on wild species.

A typical Pueblo III staple, *Opuntia* seeds may situate the use of this expedient fire in late summer, early fall or later (in the vicinity of the site prickly pear fruit develop in July and August and typically drop in September [Johnson 2000]). Adams [1993b:14] notes full flowering for *Opuntia* [c. *phaeacantha*] in late June, with immature fruits persisting into early October and some remaining until the following June). Hough (1897) records that the Hopi boiled and ate stems of *yün'yü* (*Opuntia*) in the spring, the seeds in archaeological contexts may be incidental evidence for use of other parts. The use of a necessary technology for harvesting in the form of cactus tweezers (Cushing 1920), hints at the planning for prickly pear cactus pads and flower harvest. Split twigs might reflect something of this connection. A (split?) juniper wood slat found in room 1205 (CCAC 2004, Structure 1205 Wood slat (*Juniperus*-type), PL7, photograph number 3895) appears large enough for the purpose. Cushing records the construction of *Opuntia* collecting baskets and processing of the plants for the Zuni (again basketry remains were found in room 1205). *Opuntia* was collected in "dry season or wet" with "ancient folklore teeming with allusions to it" (Cushing 1920:237, "Food of the Ancients"). The encoding of the importance of prickly pear in ceremony and story highlights the plant's potential spiritual and social content (chapter six, pp.161-162).Considering the advice of VanDerwarker and Peres (2010) to incorporate artifactual and faunal evidence in assessments of food preparation, I reviewed the artifact and faunal record for this unit. Fragments of *Canis* spp. (dog/wolf/coyote), *Meleagris gallopavo* (turkey), *Neotoma* (wood rat), *Odocoileus* (deer), Sciuridae (ground squirrel and rock squirrel species), and *Sylvilagus* (cottontail rabbit) remains were identified in the unit (Muir 2007, CCAC 2004, Cultural Deposits, Arbitrary Unit 1, Animal Bone Analysis Summary). The evidence of both floral and faunal remains hints at a campfire cuisine that may have consisted of bread, cactus fruits and a variety of animal protein.

In this comparison, I present an alternative explanation to resource stress as the reason for absence of food remains particularly in the case of *Zea mays* and *Opuntia.* Ethnographic campfire cuisine and evidence from coprolite studies suggest that the new sample captured typical food choices for Ancestral Puebloans. The analysis of an additional burned spot sample provided taxa that allowed for a more enhanced view of this feature type and of food preferences and preparation around ephemeral thermal features.

Burned spot comparison 2: rooms 1003 and 1008

This comparison is based on two burned spot samples located in block 1000. Both features were located inside rooms. Ephemeral fires in these locations appear to be linked to catastrophic or post-catastrophic residency identified as circa A.D. 1277 or shortly thereafter. These features may reflect the continued presence of attackers in the area. The new sample (FV2) was collected from structure 1003, a large room with a partial flagstone floor and no evidence of a hearth or firepit. The room was accessed by a silled doorway located approximately 1.3 m above the level of the flagstone floor. Little else is known about the room. The burned spot was located on the floor surface directly in front of a raised sill doorway that led to the courtyard (1016) that surrounds the kiva (kiva 1004). FV2 (PD 816, FS 2) was collected from a burned spot described as "a shallow area of oxidation" located in the center of the southeast half of the room and measured 70 cm in length, 60 cm in width and 1 cm in depth. Although there was no formal hearth or firepit and no doorway at surface level, the presence of useable items suggested that the room was for habitation (CCAC 2004: Rooms, Structure 1003). The sample was originally 1000 ml in pre-flotation volume and produced 73 ml of total light fraction of which I examined 40.6 ml. I subsampled the .71 and .25 mm particle size because of excess retained sediment in these portions. As few burned spot samples were available for comparison, sample (CV2, "volume 1,"/PD 856 FS 1) was used to compare burned spot contents within the confines of the same architectural block in abandonment contexts.

The comparison sample (CV2) was collected from roof fall that accumulated in the lower storey of the tower (room 1008) possibly originating from the tower's inferred upper storey room 1019 that collapsed into the space (chapter seven, pp. 209-210). The burned spot (feature 3) was recognized in a roof fall layer. The measurements are recorded as 65 cm in length, 65 cm in width and 1 cm in depth. A pottery sherd was present in the ash (CCAC 2004: Rooms, Structure 1008, Feature 3). Sample CV2 was collected from the burned spot (feature 3) recognized in a roof fall layer. The measurements of the burned spot are recorded as 65 cm in length, 65 cm in width and 1 cm in depth. A pottery sherd was present in the ash (CCAC 2004: Rooms, Structure 1008, Feature 3). All data is summarized in Table E.2 (Appendix E).

Original findings: volume 1 (CV2)

Four genera/species are documented for this sample (Table 7.4). These consist of maize and a variety of wild plant seeds: cheno-am, *Physalis longifolia* (common groundcherry) and *Portulaca retusa* (purslane). An unidentified bud was noted. No fuel wood types were identified. The ash from the feature was clearly distinguishable from the surrounding debris although fragments of fuel wood may not have been which might explain the absence of shrubs and tree remains. These specimens might account for six inference values of use and ecology. The presence of edible maize suggests the cooking of ground or parched corn. Two weedy plant types point to food preparation and seasonality of use: for *Physalis longifolia*, the seeds/fruits are available in the fall, *Portulaca retusa* seeds set in the summer at SCP (Adams et al. 2007:Table 17). Seasonal availability allows for speculation about when these plants were harvested and if they could represent stores. Cheno-am seeds (either goosefoot or pigweed) in summer or fall more likely reflecting the use of seeds as ingredients in flour as the greens would be more typically harvested in the spring. Even with little light fraction the number of taxa identified in this sample is considerable, providing clues as to the use of fruits and ground or parched corn or cornmeal.

New findings: FV2

Nine new genera/species were identified in this sample consisting of a variety of fuel materials that include nonshrubby and shrubby charcoal types: *Juniperus* and *Pinus edulis*, *Amelanchier/ Peraphyllum*-type, *Artemisia tridentata*, *Cercocarpus*, *Chrysothamnus* (rabbitbrush), *Quercus* (oak) and *Salix* (willow).[85] The remains of pine cones, umbos, bark scales, and shrubby twigs from serviceberry/peraphyllum and big sagebrush I have categorized as tinder-types. Wild food-type resources include *Physalis longifolia* and *Oryzopsis hymenoides* (Indian ricegrass, also known as *Stipa hymenoides*), both weedy species. I found no evidence of maize, cheno-am or purslane. The inference potential for these taxa encompass some 15 interpretive values, 13 of which provide new information about burned spots, particularly the burned spot in room 1003. As latest or abandonment deposits, new findings provide some general information about plant use in latest occupation, or catastrophic settings. Of the nine new plants I identified from sample FV2, seven were not previously encountered in any burned spots analyzed for SCP. These are: *Cercocarpus*, *Chrysothamnus*,

[85] Cottonwood/poplar (*Populus* sp.) and willow (*Salix* sp.) are difficult if not impossible when charred, to distinguish between. I have identified willow based on good matches from my own comparative collection of charred willow and cottonwood stems. On cross-section, willow pores are more defined than those of cottonwood although this may be the result of aged stems versus new, typical burn patterns or longer burn times. My comparative samples of cottonwood lose their clarity with distinctively different pith morphology (Willow small, highly light reflective; Cottonwood, star-shaped, no light reflection). Alden (2012a, 2012b) documents one difference between cottonwood and willow morphology on radial section: cottonwood/poplar have homocellular, uniseriate rays, willow has heterocellular, uniseriate rays. I could not identify this distinction so the identification is tentative. Tennessen et al. (2002) highlight the importance of distinguishing between highly similar wood morphologies. In their study, they assess cottonwood and aspen that shared very similar traits. We typically think of willow for basketry and cottonwood for fuel or building materials. Tennessen and colleagues recommend that it would be interpretatively important to distinguish between the two rather than presume fuel wood, although I do not do this here. Charred wood remains do not necessarily reflect deliberate *fuel* choices but could serve as useful for many aspects of daily life (Adams 1988:404-415).

Quercus, *Juniperus*, *Pinus edulis*, *Salix* (a tentative identification but the *Populus/Salix*-types [cottonwood/willow] is new to burned spots regardless) and *Oryzopsis hymenoides*. FV2 also contained a quantity and quality of remains that suggest more resources were used in and around these primary refuse feature types than previously known. Indian ricegrass is noted in only two samples examined for the final report (Adams et al. 2007) and those were from contexts that researches associated with "earliest" occupation use. This sample confirms that Indian ricegrass was also used in latest occupation thermal features. Suggested inference values are outlined in Table 8.3.

Table 8.3 Suggested inference potential: burned spot comparison 2 (charred remains).

Interpretive category	Burned spot room 1008 volume 1 (CV2)	Burned spot room 1003 new volume (FV2)	New taxa[a]
Foods			
Domesticates (FD)	*Zea mays*	-	-
Wild resources, weedy (FW)	Cheno-am	-	-
	Physalis longifolia	*Physalis longifolia*	-
	-	*Oryzopsis hymenoides*	*Oryzopsis hymenoides*
	Portulaca retusa	-	-
Wild resources, nonweedy (FN)	-	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	-	*Juniperus*	*Juniperus*
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	-	*Amelanchier/Pera.*[b]	*Amelanchier/Pera.*[b]
	-	*Artemisia tridentata*	*Artemisia tridentata*
	-	*Cercocarpus*	*Cercocarpus*
	-	*Chrysothamnus*	*Chrysothamnus*
	-	*Quercus*	*Quercus*
	-	*Salix* (cf)[c]	*Salix* (cf)[c]
Zea mays cob remains (FLZ)	-	-	-
Tinder types (FLT)	-	*Pinus edulis/Pinus* sp.	*Pinus edulis/Pinus* sp.
	-	*Amelanchier/Pera.*[b]	*Amelanchier/Pera.*[b]
	-	*Artemisia tridentata*	*Artemisia tridentata*
Other			
Other, ecological (OE)	Cheno-am [summer]	-	-
[seasonality]	*Physalis longifolia* [fall]	*Physalis longifolia* [fall]	-
	Portulaca retusa [summer]	-	-
	-	*Oryzopsis hymenoides*	*Oryzopsis*
Other, unknown (OU)	-	[spring/summer]	*hymenoides*[spring/summe
Other, worked (OW)	-	-	r]
	-	-	-
	-	-	-
			-
Genera/species count	**4**	**10**	**9**
Inferred interpretative value	**7**	**15**	**13**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

[b] *Amelanchier/Peraphyllum.*

[c] Identification compares favourably to the genus noted.

Oryzopsis hymenoides is a historically significant resource. Doebley (1984) records Indian ricegrass as a diet staple that was used extensively in the historic period. Stevenson (1915:67) writes of the Zuni, "since the introduction of corn, it has been the custom to combine the ground *Ericoma* (Indian ricegrass) seeds with meal and water" to make balls or patties which are steamed similar to the previous recipe for "small seeds" I included in burned spot comparison 1. Fewkes' (1896) suggests that Indian ricegrass has linguistic associations to social structure for the Hopi reflecting the cultural importance of the plant.[86] The seasonality of ricegrass may also be important in archaeological contexts. Doebley (1984) situates the flowering of Indian ricegrass from June to August suggesting a summer season of seed production in Arizona and New Mexico. Adams et al. (2007: Table 17) records the presence of Indian ricegrass flowering in the Sand Canyon area as the spring months of April, May and early June. The grain is one of the largest of the grasses and the plant thrives in disturbed habitats making it a predicable plant in areas of human occupation. It was assessed as "probably the most valuable wild cereal" for Southwestern groups (Doebley 1984:59). The timing of use of the burned spot in room 1003 is not easily explained by the presence of fall and spring/summer season resources (common groundcherry and ricegrass) although minute seeds could persist on floors and in buildings, the result of ancient "used" seed rain. The high relative abundance of ricegrass grains (21 specimens) in the burned spot sample as compared to one specimen of common groundcherry recovered in the same sample could be the result of the use of stored seeds in a campfire setting. In terms of fuelwood, juniper and pine are consistent in quantity based on multiple samples from most contexts. The environment around Sand Canyon today is abundant with shrubs and ethnographic sources record that many dried shrubs were collected and stored as fuel sources. The quantity of shrubs in a room setting is high but not wholly unexpected. The combination of species suggests specialized activities such as those associated with special groups and clan rooms as noted in Fewkes (1902).

The faunal remains associated with these features may offer some additional insights. Room 1003 (FV2) contained remains of deer mice, voles and small rodent of wood rat (*Neotoma*)-size or smaller. Room 1008, the lower storey tower room located just outside 1003 contained of a wider variety of animal remains. Deer, deer-sized remains, turkey, large birds (possibly turkey but

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[86] Hough (1897:37) records *léhü*, the Hopi name for Indian ricegrass, was used in "ancient times for food." Fewkes (1896:17) makes the following observations for the same grass identified as *Oryzopsis cuspidata*, (*Ericoma cuspidata* Nutt.) as name given to one of the Hopi clans associated with the Flute clan and notes that the term *léhü* could possibly come from *leñya* (flute, reed whistle) and *cühü* (meaning: hay). Whiting (1939:46-47) confirms that "Indian millet" (*Oryzopsis hymenoides*) is a Hopi clan, and a grass, he notes as "once an important source of food." Cushing (1920:219) writes of a "family meal of grass seed" (unspecified type) from his time living with the Zuni between 1879 and 1884. This he classifies under the heading, *I′no-te-kwe a-wen I′tâ-we*, or Zuni for "Food of the Ancients" (216), referring later to *te′-shu-ko'na* ("that searched for") for a "kind of wild rice" that I suggest may also be Indian ricegrass (246). It is interesting to note that some clan names are recorded as being from older times, some named for plants (or other beings) that were no longer part of activities and subsistence of the historic Puebloans as reported to these authors.

unidentifiable), *Canis* sp., and cottontail rabbit remains were identified in this context (Muir 2007). Muir (2007:para. 48-52) speculated that the comparative distribution of remains of deer (in addition to pronghorn and sheep) was patterned and more abundant in D-shaped tower rooms, including room 1008, and in the D-shaped building in abandonment contexts and roof fall deposits. Communal hunting or feasting activities may leave such a signature, the structures potentially associated with particular, and presumably distinct, groups of people and the socially prescribed discard of animal bones. The use of campfires as opposed to more formalized firepits or cooking hearths does suggest something other than typical daily meal preparation was occurring in and around these features.

<u>Burned spot summary (Table F.1, Appendix F)</u>

Increasing the number of flotation samples by only two litres provides new information about the use of plants in expedient fires inside structures and outside the site-enclosing wall. The identification of pinyon pine charcoal, not noted previously, in these feature types or elsewhere, was recovered in new samples, the context of one comparison situated at the end of the occupation, a time when pinyon pine use is interpreted to be on the decline as the result of inferred overharvesting for fuel wood (Adams et al. 2007). These specimens could represent re-use of old or scavenged construction beams or availability on the landscape. Mountain mahogany, a shrub that was previously "absent" in burned spots, was found in both new flotation samples. Oak, rabbitbrush and willow (or *Populus* [cottonwood]), trees and shrubs previously undocumented for burned spots were recovered in an interesting combination suggestive of either typical use as noted in the ethnographic record (shrubs being used in historic fires), expanding fuel needs, or simply convenience. *Populus/Salix* charcoal is not commonly identified at SCP and historically is tied to the making of ritual objects. Certain shrubs were used in kiva fires associated with important spiritual activities. Although it appears that typical Pueblo III food resources were used in association with sample FV2, the sample also contained evidence of *Sphaeralcea* (globemallow). While uncharred, this species of Malvaceae is intriguing when considering context: a large room associated with a D-shaped defensive tower that may have been a focused space for clan or other group activity, a wide variety of shrubs some used historically in the preparation of ritual, a pharmacologically active plant family and similarities with tower 101 archaeobotanical record and apparent familial connections between residents. The root of *Sphaeralcea* is connected with Zuni ceremony and the Great Fire fraternity (Stevenson 1915:98).

Evidence of big game supports the ubiquity of *Opuntia* seeds in latest occupation samples as representative of fall season activity. In their analysis of Sand Canyon Pueblo and Sand Canyon Locality sites, Adams and Bowyer (2002) did not support differential use of plants or starvation foods at Sand Canyon Pueblo although they recognized that an increased ubiquity of *Opuntia* (prickly pear) seeds in latest occupation fires. *Opuntia* seeds are available in quantity in the fall, another consistency that suggests a deliberate fall resource strategy. The historic record of clans, dances and ceremonies associated with *Opuntia* provides alternative explanations for the importance of *Opuntia*. As an element in a pre-maize milled food, the seeds in latest occupation contexts suggest a connection between fall hunting, pre-maize harvest, typical foods and, in the case of block 100, the use of the plant for medicinal purposes. A comparison of the data by feature type are presented in Appendix F

Firepits

Unlike burned spots, firepits are not ephemeral features. They are typically used over time, are less formally constructed with sides and plaster as are hearths, and many are excavated into floors and other surfaces and lined in some manner. Adams et al. (2007:para. 51-52) interpret the firepits at SCP as used less extensively for cooking than hearths. The distribution of firepits is scattered across the site and most are located in rooms, although not all. Several firepits were located in courtyards and other outdoor locales. Plant remains that might be represented in firepits would presumably include a variety of common fuel wood types and a range of plant remains, although perhaps less formally organized than a meal in a hearth setting. Alternative explanations of firepits at SCP include the outdoor processing of plants for dye and as fires in clan or special use rooms for the processing of medicines in addition to the need for heat and light especially in the fall, winter or early spring. From their original pithouse configuration below ground into above ground residences, over time kivas became more highly ritualized and restricted spaces even as early as Pueblo III (Mobley-Tanaka 1997:446; footnote 32, p. 135). By the historic period, rooms were the main residential unit but some were restricted spaces for the preparation of kiva ritual and the management of secret knowledge (Fewkes 1902). SCP kivas were thought to be largely residential with hearths the dominant cooking features. The firepits at SCP indicate that specialized activities did take place in rooms; the apparent activity areas in rooms in block 100 attest to ritualized spaces. Based on availability and comparability, samples were selected from three firepits. Of these, two (samples FV3 and FV4) are compared to samples excavated from the same deposit. Sample FV5 is compared to a sample from a second firepit located in the same room. All data are summarized in Appendix E and in the summary tables by feature type in Appendix F.

<u>Firepit comparison 1: outdoor courtyard</u>

Sample FV3 and its comparison volume (CV3) were recovered from a shallow firepit (feature 5) located midway along the west wall of courtyard 1000 (pp. 210-211). The firepit measured 46 cm in length, 42 cm in width and 6.5 cm in depth (the top of the feature may have been excavated before it was recognized as a firepit). It was encountered below a use surface and surrounded by old construction fill (CCAC 2004: Extramural Surfaces, Nonstructure 1000, Feature 5). Based on the estimated construction date for the courtyard (A.D. 1266), and sample provenience in construction fill, I estimate that the plant remains recovered represent a period of ideological expansion. This situates the courtyard refuse during the construction of the block, the great kiva's peripheral rooms, and the D-shaped building. If this is an accurate assessment, the remains represent firepit material prior to major shifts in behaviour or remodeling events and the final transition of the courtyard to a midden. The new sample, FV3 (PD 849, FS 2), measured 950 ml prior to flotation and produced 30.5 ml in total light fraction. I subsampled the .71 and .25 mm screens due to excessive microscopic sediment and examined the entire 1.4 mm particle size in an attempt to compensate. I examined 23.4 ml in all. I compared my findings to a previously analyzed 1000 ml flotation sample, CV3, ("volume 1," PD 849, FS 1) from the same firepit. The original sample yielded 21 ml of total light fraction; all reportedly examined by the original analysts. Both volumes contain similar remains.

Original findings: CV3

Juniperus and *Pinus* charcoal and maize cupules were identified as fuel sources. Two wild and weedy food plants, cheno-am and *Physalis longifolia*, were documented, likely representing the accidental discard of plants used for food, whether used for the seed or for other parts of the plant.

New findings: FV3

In addition to juniper, pine and maize remains, the new sample contained a number of *Pinus* bark scales typically interpreted as tinder material. This sample contained one specimen of *Portulaca retusa*, a summer weedy food source. Historically used with ground maize, the relative quantity of this "caterpillar, his corn" (Fewkes 1896:15; see footnote) is higher than the original volume.

The original sample produced five taxa with seven possible inferences. The new sample provided four taxa, six potential inferences, one to three of these are considered new for this firepit. When the data from both samples are combined, the firepit provides evidence of economically important wild resources, some commonly associated with disturbed areas and agricultural fields (see Adams et al. 2007: para. 43, 47). The contribution of an additional sample provides evidence of a new weedy annual, purslane, a summer resource and supports summer as a possible season of use (Adams et al. 2007: Table 17). Purslane was found, previously in only two of the 19 firepit flotation samples examined for SCP, although it is noted in three originally examined burned spot samples (CCAC 2015a). The new sample is therefore important for its contribution of this wild seed type. The ethnobotanical record provides some detail about the cultural importance of purslane.Table 8.4 (over) provides a breakdown of interpretative values for both samples.

Table 8.4 Suggested inference potential: firepit comparison 1 (charred remains).

Interpretive category	Volume 1 (CV3)	New volume (FV3)	New taxa[a]
Foods			
Domesticates (FD)	-	-	-
Wild resources, weedy (FW)	Cheno-am	-	-
	Physalis longifolia	-	-
	-	*Portulaca retusa*	*Portulaca retusa*
Wild resources, nonweedy (FN)	-	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	-
Shrubby growth habit (FLS)	-	-	-
Zea mays cob remains (FLZ)	*Zea mays*	*Zea mays*	-
Tinder types (FLT)	-	*Pinus*	*Pinus*
Other			
Other, ecological (OE)	Cheno-am [summer]	-	-
[seasonality]	*Physalis longifolia* [fall]	-	-
	-	*Portulaca retusa* [summer]	*Portulaca retusa* [summer]
Other, unknown (OU)	-	-	
Other, worked (OW)	-	-	-
Genera/species count	**5**	**4**	**1**
Inferred interpretative value	**7**	**6**	**3**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

K'u'-shu-tsi, or purslane was the "first among [the food seeds]" for the historic Zuni (Cushing 1920:244, 258) and categorized as equally important as *Chenopodium*. The seeds were stored away for use with corn, saying by so doing, they were "nourishing themselves with ... the food of their forefathers, [and in so doing] they partake of the hardihood, courage, wisdom, and possibly some of the supernatural qualities with which they fail not to endow their remote ancestors."[87] The importance

[87] An unspecified botanical type of purslane (*Portulaca* sp.), or *k'u'-shu-tsi* (Zuni) is documented by Cushing (1920:244) under the heading, "Food of the Ancients," reflecting the traditional use of the plant prior to the early 1900s. Purslane plants were harvested before the ripening of the seeds, then dried and threshed by pounding the entire plant over "mats or screens" and/or sweeping up the floor surface to recover the minute, starchy seeds followed by winnowing to remove the seeds from sediments. The Hopi's use of purslane or, *piha´la* (*Portulaca oleraceae*, L.), receives hardly a historic mention in Whiting (1939:75), briefly recorded as being used in a gravy. One of Whiting's consultants however translated the Hopi name as "referring to a caterpillar," or as Fewkes (1896:15) writes, the plant was called *piakü kaüadta*, "caterpillar, his corn," and was boiled with meats by Hopi. The prickly surface and curled shape of the seed fits well with this description and links with corn in naming suggests a recognition of the plant's importance. No mention of either group using the plant as greens is noted in these sources. According to the United States Department of Agriculture Natural Resources Conservation Service (USDA, NRCS 2015), *Portulaca retusa* Engelm., *Portulaca neglecta* Mack. & Bush, and various subspecies of *Portulaca oleracea* are introduced species to all American States and native to Canada and are synonyms for *Portulaca oleracea* L. (little hogweed). The presence of purslane in archaeological sites and the characterization of the species as introduced after contact is not supported by ancient coprolite evidence. Hall (1979:240) confirms that purslane was "one of the 'top nine' dietary items" found in coprolites at Antelope House.

of purslane for Ancestral Puebloans as a food source is confirmed by coprolite evidence (Hall 1979:240; Reinhard, 2000; Sutton and Reinhard 1995).

Common groundcherry seeds recovered in the original sample, typically available in early fall (up until first frost), situates the deposit later in the year and purslane likely representing stored seeds. Because of the original exposure of the firepit is in the context of an open courtyard, seed types such as groundcherry, cheno-am and purslane would easily be introduced into such a feature, regardless of the season of use. Specimens with little additional interpretative value are the typical bark scale tinder-material so often present in thermal features and expected when burning pine wood and twigs. All data, including nonbotanical and other remains, collected from both samples are presented in Table E.3 (Appendix E). The faunal evidence associated with surface 2 of the courtyard consisted of the identification of two turkey bones, neither found in the firepit.

The firepits at SCP are generally noted to be high in taxonomic richness making this firepit, based on the analysis of two flotation samples, somewhat unusual for its apparent *absence* of remains. The deposit may have been disturbed, cleaned, or simply does not conform to the known patterning identified in the final report. The exposure of the firepit prior to the overlay of an additional use surface would have been vulnerable to ancient seed contamination. There is a small quantity of disturbance-related debris (insect parts, uncharred remains etc.) noted for FV3 that would be expected in a feature exposed to the elements. The possible non-recognition of the feature could be a contributing factor in the results. Although the additional sample provided limited new information, the presence of purslane only recorded in one other flotation sample (from an "earliest" context) makes this new sample important for a more enhanced interpretation of the feature. The Zuni "first food" seed or "seed of seeds" (Cushing 1920:289) and the Hopi association with "caterpillar corn" confirms that purslane was culturally important during the historic period and metaphorically associated with corn. The size of these seeds must be considered in any assessment of abundance or ubiquity. Most likely to be found in the .25 mm light fraction screen, purslane seeds would be subject to SAC subsampling. An additional single one-litre flotation sample is unprocessed and archived for this firepit. Future analysis may contribute additional information.

<u>Firepit comparison 2: room 1005</u>

This comparison is an evaluation of two samples collected from a firepit located in room 1005, one of such features found in a room interpreted to be a "living room" (CCAC 2004: Rooms, Structure 1005)(chapter seven, p. 210). Its proximity to the D-shaped tower (1008/1019) situates its use within that context. The use of the firepit (feature 4) is described as occurring sometime after A.D. 1266 based on estimated construction dates for the courtyard. The firepit was sealed over at some point, the content excavated found between three defined surfaces. Centrally located within the room, it was basin-shaped and informally constructed measuring 40 cm in length, 40 cm in width, and 5 cm in depth (CCAC 2004: Rooms, Structure 1005). Based on provenience, I estimate the sample content reflects original activities associated with this room circa A.D. 1260s. The sealing over of the firepit also sealed in plant remains. I assess changes in room use as being associated with major transitions we see in the D-shaped building some time after ca. A.D. 1274-75.[88] In this respect this firepit may have been in use in the phase of "normalcy" for SCP, occurring prior to shifts in behaviour seen throughout the pueblo. This situates deposition in the A.D. 1260s, a period distinguished by ideological expansion with the construction of public architecture.

New sample FV4 measured 1000 ml before processing and produced 50.5 ml of light fraction. I subsampled the two smallest screens using SAC standards but examined the entire 1.4 ml screen for a total of 29.2 ml examined. The results are compared to a previously analyzed 1000 ml sample (CV4, "volume 1," PD 847, FS 2) also taken from the same firepit and surface. Thirty-three ml of total light fraction volume was recovered from this sample and 32 ml was examined. It is unclear whether subsampling occurred or if the 1 ml of unexamined material was retained in the catchpan screen, which is not examined. Data collected from both samples are presented in Table E.4 (Appendix E).

Original findings: CV4

CV4 contained *Juniperus osteosperma* (Utah juniper) scale leaves and *Juniperus* charcoal. A quantity of *Pinus* bark scales are recorded. Additional fuel wood types include *Prunus/Rosa* (chokecherry/rose-type) and *Fraxinus* (ash)(recorded as a tentative identification). The presence of a single charred *Physalis longifolia* seed suggests the use of a wild food resource, possibly indicating an early fall deposition (Adams et al. 2007:Table 17).

New findings: FV4

FV4 contained additional fuel types and includes *Juniperus*, *Pinus edulis*, and the remains of various shrubs: *Amelanchier/Peraphyllum, Artemisia tridentata*, *Atriplex* (saltbush) and *Cercocarpus*. I have interpreted the occurrence of single *Zea mays* cupule as evidence of the burning of maize cobs as fuel. The presence of several kernels in this sample supports the view that maize was also a food resource accidentally burned in the firepit, an assessment consistent with the final report and historic practice.

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[88] The replastering of floors and walls in the D-shaped building would have been annual events if historic practice applies. As kiva 1502, the west kiva twin was estimated as built in A.D. 1270-71, four plastering events would place its change in use circa A.D. 1274-1275. I estimate these are foci dates for major transitions at Sand Canyon Pueblo. The other plausible explanation is that transitions occurred after A.D. 1277 when the last construction beam was cut. The problems of temporal control are evident and my assessments obviously tentative.

Additional specimens include a festucoid-type grass (Poaceae [festucoid grass]) caryopsis and a grass stem fragment, catalogued as “Poaceae type B” defined by distinctive morphology and surface characteristics (for a description see Appendix C, photographs D.38-D.40, Appendix D). A charred leaf compared well to bitterbrush (*Purshia tridentata*). Six unique taxa were originally identified as remains of activities involving plants in and around the firepit. Seven interpretative values representative of the use of both shrubby and nonshrubby fuel sources and the accidental discard of a wild, weedy food resource are plausible. This could situate the last use of the feature in the fall. The breakdown of taxa and associated values for both samples are presented below (Table 8.5).

Table 8.5 Suggested inference potential: firepit comparison 2 (charred remains).

Interpretive category	**Volume 1 (CV4)**	**New volume (FV4)**	**New taxa[a]**
Foods			
Domesticates (FD)	-	*Zea mays*	*Zea mays*
Wild resources, weedy (FW)	*Physalis longifolia*	-	-
		Poaceae (festucoid)	Poaceae (festucoid)
Wild resources, nonweedy (FN)	-	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Fraxinus* ‡	-	-
	Prunus/Rosa ‡	-	-
	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
	-	*Artemisia tridentata*	*Artemisia tridentata*
	-	*Atriplex*	*Atriplex*
	-	*Cercocarpus*	*Cercocarpus*
Zea mays cob remains (FLZ)	-	*Zea mays*	*Zea mays*
Tinder types (FLT)	*Juniperus osteosperma*	*Juniperus osteosperma*	-
	Pinus	*Pinus*	-
	-	*Pinus edulis*	*Pinus edulis*
Other			
Other, ecological (OE) [seasonality]	*Physalis longifolia* [fall]	-	-
Other, unknown (OU)	-	Poaceae (type B)	Poaceae (type B)
	-	*Purshia tridentata*	*Purshia tridentata*
Other, worked (OW)	-	-	-
Genera/species count	**6**	**11**	**9**
Inferred interpretative value	**7**	**14**	**11**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

‡ Identification noted to be “questionable.”

The additional flotation sample contained eleven taxa contributing 14 inferences of use and ecology, eleven of which are new or provide enhanced information about the activities associated with the feature. In terms of shrubby taxa, serviceberry/peraphyllum and saltbush were previously recorded for only one of the twelve firepits originally analyzed for the 2007 final report. Big sagebrush and mountain mahogany are recorded for two previously analyzed firepits. Bitterbrush has not been identified previously although bitterbrush/cliffrose (*Purshia*-type) has been recorded (note: it is difficult to distinguish between cliffrose and bitterbrush charcoal because the morphology of charred remains is indistinguishable, the leaves are the basis for identification – this ambiguity is discussed in further detail later in this chapter). Poaceae/Gramineae stems were not previously identified in thermal features and only one specimen recorded for the site.

The ethnobotanical record may offer some insights into possible uses of shrubs in this firepit. *Artemisia tridentata* Nutt. (Hopi: *napalü'ña*) leaves are recorded as medicine, used in an infusion (Hough 1897:42). The same species, known as *hovápi*, is or was used in the flute paho (prayerstick)(42). The ashes of saltbush (*Atriplex* sp.) were traditionally mixed with blue corn in the preparation of blue wafer (Hopi *piki*) bread (Whiting 1939:73). *Atriplex canescens* (Pursh) James (fourwing saltbush) was recorded as used for Zuni prayer-sticks when associated with the winter solstice and prayers for a good cottontail rabbit hunt (Stevenson 1915:88). Hough (1897:42) records this species, named *süóvi*, as one of the four Hopi ceremonial kiva fuels. Additionally, *Atriplex confertifolia* (shadscale saltbush) leaves were traditionally boiled in the water used to mix corn pudding (38 [Hopi]). Mountain mahogany or *putci'vi* (specifically identified by Whiting [1939:27; 78] as *Cercocarpus eximius* [C.K. Schneid.] Rydb.) was used as a dye, the wood made into batons and combs for Hopi weaving. *Purshia mexicana/Cowania Mexicana* Torr. or *Stansburiana* sp. (cliffrose) bark, historically known as *hu:'nvi* by the Hopi, was used as padding for cradleboards and often mistaken for juniper bark (78). The straight limbs of cliffrose were historically desirable for arrow shafts. Boiling the twigs and leaves creates a gold dye, if added to powdered juniper a tan dye can be achieved (Dunmire and Tierney 1997:170). Cliffrose is also considered a major dye plant for the Navajo (the Navajo use the same word for both baby cradle and the cliffrose plant). Used as medicine with cosmological associations, the plant is identified with the southeast direction of the Hopi *Powamuy* altar used in the *Powamuy* ceremony occurring in February,[89] the bark historically woven into the kilts worn by snake priests (Whiting 1939:78; 80-81). The leaves when used for medicine were known by the less common name of "quinine bush" alluding to the potential medicinal properties (Dunmire and Tierney 1997:169). Dunmire and Tierney 1997:168) write that contemporary groups do not distinguish between cliffrose and bitterbrush. As tempting as it may be to associate the

[89] Voth (1901) observed the Hopi *Powamu*y ceremony at Oraibi, west Mesa, Arizona (the seventh Hopi village), in late January or early February of 1894, 1896, 1897, 1898, and 1901. Whiting's (1939) Hopi ethnobotany describes the *Powamuy* as the "Bean" Ceremony where beans (including *Phaseolus vulgaris*) and maize are planted in the "super-heated" kivas in February as a "kiva crop." The *Me'y'ingwa*, the spirit of germination is said to send up the plants and fruits from the underworld (82), much as the people, like plants, ascend into the world above. "The success of the crop is supposed to foreshadow the harvest of the coming season" (Whiting 1939:41-42). Whiteley's description of the *Patsavu* ceremony, the "beautifully ascended" return of the Badger clan to Orayvi at the behest of the Bear clan (1998:110-114) and its association with Powamuy provides the clarity original ethnographers may not have grasped. See also p. 475 here.

remains of *Purshia*-type twigs and wood with simply fuel materials, the ethnobotanical record demonstrates an array of possible explanations as to why the plant may be present in archaeological deposits. *Purshia*-type remains were previously accounted for in one burned spot outside the site-enclosing wall (burned spot 1 comparison, sample CV1b), a cache of *Purshia* seeds was found in block 1200. However, Rose family species such as *Purshia* are found with regularity in association with juniper and pine charcoals in thermal features giving us indication of a cultural preference for these Rose-species for fuel

In addition to *Purshia,* the value of the additional sample is the evidence of the variety of shrubs, identification of pinyon, and the presumably accidental discard of grass seed and stems. The presence of grass parts may simply represent grass use as a tinder material without regard for edible seed, although the variety of shrubs suggests more going on around this firepit than just a wide selection of fuel types. If the last use of the feature was indeed in the fall, the presence of maize kernels might reflect recently harvested food resources, stored food or the typical use of ground or parched maize as suggested in the ethnographic literature. Regardless, this firepit was not cleaned prior to the application of a new floor surface. Because of the proximity to the D-shaped tower room (structure 1008) and evidence of clan or society activities occurring early in the occupation of this block and late activities in block 100, I contend that the sealed firepit in room 1005 reflects preparation for such events. The plant record for this room seems to fit well with plants typically associated with the making of prayer-sticks, dyes and presumably other ceremonial objects that occurred in similar rooms in the historic period. The inference potential of this firepit and firepits in general are enhanced with the addition of the single new one-litre flotation sample in this comparison. No other samples were excavated and the two samples presented here are presumed to represent the entire deposit.

<u>Firepit comparison 3: lower storey D-shaped tower room 1008</u>

This comparison is based on two samples recovered from two separate firepits located in the lower tower room 1008 in block 1000 (chapter seven, pp. 209-210). The contents of the samples represent activities associated with earlier use of the room prior to the application of a new floor in a time I estimate as the A.D. 1260s, a decade that is most associated with the expansion of the great kiva and construction of the D-shaped building. The sealing over of the firepits with two layers of adobe plaster 4 cm thick during the application of a new floor surface intimates a shift in how the tower was used suggesting change where firepits were no longer required. The room is interesting for its architecture, its artifacts and its height. Like the Warriors' Room at Walpi, the room was low. Adults would have found it difficult to stand upright in room 1008. Artifacts found here include jewelry, a polishing stone, an axe, a projectile point, eggshells, shaped slabs, many pottery sherds from jars and bowls and animal bones (CCAC 2004, Rooms, Structure 1008, Artifact Inventory) all associated with the latest surface that apparently covered the firepits. Around A.D. 1277 the room was also the site of significant violence with the careless and callous disposal of human remains. A previous burned spot sample from this later context was examined for this room (CV2). Rooms located nearby are 1002, 1003, and 1005, these and the courtyard (nonstructure 1000) could shed light on activities in the tower prior to shifts in behaviour that seemingly occurred in the mid A.D. 1270s.[90]

Sample FV5 (PD 875, FS2) was collected from the northwest corner firepit (feature 2), identified for the purpose of this comparison as the NW firepit. The feature measured 43 cm in length, 36 cm in width, and 10 cm in depth and was lined with clay. It contained charcoal fragments and chunks of red clay and was sealed over with a floor surface. Comparison sample (CV5) was recovered from the second sealed firepit (feature 1) located in the southeast section of the room. This firepit measured 75 cm in length, 57 cm in width, and 9 cm in depth and was lined with clay and similarly sealed. CCAC excavators recorded the presence of bone, corn, wood and charcoal in the feature (CCAC 2004: Rooms, Structure 101). All data are summarized in Table E.3 (Appendix E).

The FV5 sample originally measured 700 ml and produced 47.5 ml of light fraction. I examined the 1.4 mm portion in its entirety and subsampled the .71 and .25 mm portions because of excessive sediment in these screens and scanned a total of 27.5 ml. The results are compared to a sample CV5 ("volume 1"/PD 874, FS 5) from the second similarly sealed firepit (feature 1, now labeled the SE firepit), located against the southeast wall of the same room. Both firepits were sealed at the same time with the application of a new floor. Sample CV5 measured 750 ml in pre-flotation

[90] The rooms near the D-shaped tower room are interesting when considering the use of rooms in historic times. Fewkes (1902) reports that the room of *Püükoñhoya*, the War-God, at Walpi village on the Hopi Mesas, has a low ceiling and is entered by a ladder from the roof as if in a kiva. Situated under an "old house of the Eagle clan" the room is rectangular, has no windows and is twice as long as it is wide (this brings to mind several large rooms that were later subdivided, including room 1003). It has a small fireplace in the southwest corner of the room. Fewkes describes the room as having a small niche set into the north wall opposite the fireplace that is closed by a slab of stone and usually sealed with clay. This niche held the "idols of the God of War and other fetishes." The room was closed except for when used for secret rights of the War festival prior to which three days of meetings occur for the purpose of making certain prayer-objects and performing rites. In addition to arrows, idols and associated animals, the room contained a war-club with attached stone, a doorway to a back room, an eagle feather, a paint-stone, a wooden cross, a warrior prayer-stick, stone implements, a trail of meal running along the floor from the niche to the doorway and a tray of sacred meal amongst other features (adapted from Fewkes 1902:484-485). The construction of the prayer-stick matches the description of the construction of prayer-sticks in "The Chiefs are Instructed in Prayer-Stick Making" as told to Stephen (1929:64-65) by *Müau wataka* as recorded in *Hopi Tales* (a brief description is provided in Appendix B). Prayer-sticks or *pahos* ("rain feathers") are made of willow (*Salix* sp.) according to this source. Other researchers note different woods used in the construction of *pahos*, which may offer inference value for the use of particular wood types in firepits. The altars and outline of objects and features in the room at Walpi village as drawn by Fewkes (1902:487), may be helpful in inferring room use based on artifact type and placement. This may be applicable also to room 1003 at Sand Canyon Pueblo.

volume yielded 30 ml of light fraction of which 30 ml was examined. The comparison between the two samples sheds light on the use of firepits in similar temporal and depositional contexts.

Original findings (SE firepit): CV5

Juniperus and *Prunus/Rosa* charcoal, *Pinus* bark scales, *Zea mays* cobs and cupules were identified in this sample. Consistent with the final report, I categorize these as representing fuel and tinder-type remains. Wild resources associated with food preparation include the seeds of cheno-am, *Opuntia*, *Physalis longifolia*, and *Yucca baccata* (datil yucca). Maize kernels and fragments are likely the remains of food, perhaps ground maize or accidental deposition of parched maize. The presence of wild seeds is consistent with Reinhard's (2006) assessment of a typical Ancestral Puebloan diet.

New findings (NW firepit): FV5

This sample yielded *Juniperus* charcoal, a *Juniperus osteosperma* scale leaf, and *Pinus* bark scales. Shrubby fuel types consist of *Amelanchier/Peraphyllum*, *Artemisia tridentata*, *Cercocarpus*, *Chrysothamnus* and *Purshia tridentata* charcoal. I identified additional wild plant seeds and achenes: *Amaranthus* (amaranth/pigweed), *Artemisia tridentata* (achenes and flowering heads), *Opuntia* (evidence of ground *Opuntia* is suggested by the presence of fragments), *Polanisia* (clammyweed) and *Polygonum* (bindweed). Like the remains identified previously, these specimens also suggest anthropological and ecological values.

Eight genera/species were originally identified from the SE firepit sample (CV5). Maize remains and wild food type resources (based on parts identified) are associated with summer and fall availability providing potentially 13 inference values of food and fuel wood that were preserved under the floor plaster in this firepit. The new sample collected from the NW firepit yielded evidence of ten new species and contribute approximately twelve new inferences of use and ecology, ten species and 12 inference values are new to what we know about sealed over firepits in the tower. In addition to a variety of shrubs used as fuel, the presence of various plant parts offers an opportunity to evaluate seasonality and possible specialized use of plants. Although it is clear that food was prepared here, five new taxa are particularly interesting in the context of the tower in block 1000 and when considering the plant content in block 100: *Polanisia*, *Polygonum* and *Artemisia tridentata* achenes and flowering heads, *Chrysothamnus* and *Cercocarpus*. Table 8.6 (over) provides suggested inference values for taxa identified.

Table 8.6 Suggested inference potential: firepit comparison 3 (charred remains).

Interpretive category	Feature 1 SE firepit volume 1 (CV5)	Feature 2 NW firepit new volume (FV5)	New taxa[a]
Foods			
Domesticates (FD)	*Zea mays*	*Zea mays*	-
Wild resources, weedy (FW)	Cheno-Am	*Amaranthus*	*Amaranthus*
	Physalis longifolia	*Physalis longifolia*	-
Wild resources, nonweedy (FN)	*Opuntia*	*Opuntia*	-
	Yucca baccata	-	-
	-	*Polanisia*[b]	*Polanisia*[b]
	-	*Polygonum*[b]	*Polygonum*[b]
Wild resources, other (FO)	-	*Artemisia tridentata*	*Artemisia tridentata*
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
Shrubby growth habit (FLS)	*Prunus/Rosa*	-	-
	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
	-	*Artemisia tridentata*	*Artemisia tridentata*
	-	*Cercocarpus*	*Cercocarpus*
	-	*Chrysothamnus*	*Chrysothamnus*
Zea mays cob remains (FLZ)	*Zea mays*	-	-
Tinder types (FLT)	*Pinus*	*Pinus*	-
	-	*Juniperus osteosperma*	*Juniperus osteosperma*
	-	*Juniperus*	-
Other			
Other, ecological (OE) [seasonality]	Cheno-am [summer]	*Amaranthus* [summer]	-
	Physalis longifolia [fall]	*Physalis longifolia* [fall]	-
	Opuntia [fall]	*Opuntia* [fall]	-
	Yucca baccata [summer]	-	-
	-	*Artemisia tridentata* [achene: fall/winter, flowering heads: spring/summer]	*Artemisia tridentata* [fall/winter] [spring/summer]
	-		
Other, unknown (OU)	-	*Purshia tridentata*	*Purshia tridentata*
Other, worked (OW)	-		
Genera/species count	**8**	**14**	**9**
Inferred interpretative value	**13**	**21**	**12**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.
[b] Season of seed production unknown at this writing for *Polanisia* and *Polygonum* in the Sand Canyon area.

Ethnographic data provide clues as to plausible explanations for the use of the firepits. A species of clammyweed (*Polanisia trachysperma*) is recorded by Stevenson (1915:69) as *a'pitalu* (Zuni: "hand many seeds"). This plant shares its name with Rocky Mountain Bee Plant (*Peritoma serrulatum* [Pursh] DC) because of its similar appearance, the symbol of "hand" being representative of the shape of the leaves. The roots and flowers are used as a salve after the "last" of the Zuni Cactus fraternity dances (96). Moerman (1998:421) records the boiling and processing of clammyweed plants for greens, stews, soups, and dried for winter storage in addition to its use as a smoke plant and for other purposes in ceremony. More importantly in the context of the tower is consideration of the phytochemistry of *Polanisia* (genus: *Polanisia* Raf.). The native species found in the Sand Canyon

Pueblo area is most likely *Polanisia dodecandra* (L.) DC. subsp. *trachysperma* (Torr. & A. Gray) Iltis or sandyseed clammyweed (USDA NRCS 2015). Its effects as an anticancer agent (Shi et al. 1995) suggests medicine is a plausible explanation.

Another interesting addition to the plant record of the firepits in tower 1008 is *Polygonum*. Bindweed had several historically documented purposes; many groups used various parts as medicine (Moerman 1998:422-424). *Polygonum lapathifolium* L. (smartweed) was known by the Zuni as *ha'tashawe,* meaning "long leaf," the root boiled for an emetic and purgative tea and belonging to all Zuni clans/fraternities (Stephenson 1915:58). Other Polygonaceae (buckwheat) family members include *Eriogonum corymbosum* (crispleaf buckwheat). The historical Hopi called the plant *powawi*, a possible derivative of *powato,* associated with "a form of ceremonial purification in which this plant, or the food prepared from it, may have been used" (Fewkes 1896:21). Interestingly, Hopi *powawio pikabiki* is a type of pressed *piki* (wafer) bread made using the leaves of this species in combination with corn meal, the mealing stones for this purpose rubbed with an infusion of its leaves (21). These seeds and achenes may have inference values for situating the firepit seasonally although I could find no information for the SCP area. As an ethnomedicine, *Polygonum aviculare* (knotweed) is an herb used since ancient times in China and the eastern Mediterranean as a diuretic, for skin problems, and to treat coughs, inflammation of the mouth and upper respiratory tract. The presence of tannins and phenols in the plant are thought to contribute antimicrobial, anti-inflammatory effects (van Wyk and Wink 2004:251).

In the case of *Artemisia tridentata*, the flowers, achenes, and leaves are historically important. Big sagebrush achenes have been found in coprolites from Mesa Verde and numerous other ancient Ancestral Pueblo sites, the quantity of sagebrush coprolite evidence across the region confirms that *Artemisia* achenes were commonly consumed (Dunmire and Tierney 1997:192). The collection of *Artemisia* achenes in block 100 suggests that the use of this plant may have been medicinal.[91] The presence of achenes situates use, for whatever purpose, within a seasonal context. Collected today in early October, achenes can persist through the end of December depending on the species (USDA, NRCS 2015; see also Appendix C).

The plants recovered from two firepits in the lower storey of a D-shaped tower room suggest that each firepit may have served a different purpose. The new sample provides a wide variety of wood types, evidence of previously unknown or "rare" seeds and achenes, and fragmented maize remains (kernel, embryo) and other typical Pueblo III dietary staples (cheno-am, *Opuntia*, *Physalis longifolia*). The historic record of rooms as spaces for the preparation of medicines and ritual suggest

[91] See chapter eleven for the toxic and medicinal benefits of *Artemisia*.

that these two firepits were used for similar purposes. The variety of wild plant species is unlikely to represent the processing of unusual plants for food or simply a variety of fuel needs but rather to complement the purpose of towers in the role of defensive structures. The making of ceremonial effigies, masks, use of dyes and emetics are historically associated with ritual occasions and clan-based symbolic activities. I have presented data for tower 101 that suggest a focus space with considerable evidence of medicine. The same inference is possible here. The relatedness of individuals from both blocks provides additional support for this assessment. The re-surfacing of the floor and the sealing of the firepits may have eliminated the focus on ceremonial preparations but the recovery of a wide variety of artifacts associated with the floor of the building are suggestive of continuing special activities. The seasonality of the collection indicates a late summer or fall time frame of use, sagebrush achenes identified in the NW firepit (FV5) support fall deposition.

No additional flotation samples were excavated for either firepit. No faunal remains were found in direct association with either firepit although a variety of animal remains were identified on the same surface: deer, deer-sized animals, turkey, a very few *Canis* sp. (dog/wolf/coyote species) fragments, and cottontail. The smaller animals represent a fairly typical Ancient Puebloan protein sources, particularly fall hunting with the exception of *Canis* remains.

<u>Firepit summary (Table F.2, Appendix F)</u>

Thirteen firepit flotation samples were originally evaluated and twelve reported (Adams et al. 2007). The three new samples evaluated here provide additional new plants and enhanced interpretation of individual firepits and firepits as thermal features. The samples came from temporal contexts that I estimate are prior to transitional events (occurring sometime after A.D. 1266). These most plausibly are associated in time with the change in use of the D-shaped building that occurred some time after A.D. 1270 and the series of re-plastering events in the west kiva. More variety of shrubby taxa and wild seed types were used in firepits than previously accounted for. The D-shaped tower room in block 1000 is an interesting location, showing evidence of a change that eliminated any fire feature use. It is difficult to imagine that fires would have been built in a room of this height unless the doorway into the site-enclosing wall and a presumed hatchway cleared the room of excessive smoke. Alternatively, at some point the tower may have been only a single storey in height or the fires were well controlled. The low height of the Warriors' Room at Walpi (Fewkes 1902) is intriguing in this regard. If the height of the room reflects a secretive or sacred space, the same could be evidenced in tower room 1008.

Only two additional flotation samples (two litres of sediment) were required to provide new information about fuel types and enhanced understanding of the cooking or processing of wild plants in firepit contexts. The species area curve approach was applied to all samples and based on the results of experimental samples, it is likely that the small wild and weedy plant seeds and other reproductive parts that typically fall into the smaller screens during light fraction analysis, are underrepresented. All identified or described remains for the firepits are summarized in Table F.2, Appendix F.

Hearths

Five previously unanalyzed flotation samples were processed for this study and compared with known sample data from the same kiva hearths. All samples were collected from the central hearths of small residential-sized kivas with the single exception of a "non-typical" kiva (comparison 5). I interpret three hearths as associated with the catastrophic events of circa A.D. 1277 and the final attack (comparisons 1, 3 and 4). The content of two hearths may have been the result of earlier activities, likely transitional, occurring in conjunction with the later dismantling of buildings such as the case in kivas 517 and 1206 (comparisons 2 and 5). The samples selected for analysis here were excavated from small domestic-sized aboveground kivas interpreted as residences that perhaps served small-scale ritual areas at the household scale (Kuckelman 2007b: para.13).

Hearths are clearly bounded features, with structured bases, sides and rims. They are formally constructed with walls often plastered with adobe. Located indoors and at least somewhat protected from the elements they often contain objects such as trivet stones. Although there is a tendency for people to clean them out after use, these are main cooking features at SCP, most located in kivas. The small household scale kivas at SCP differ from the residential configurations of historic pueblos where rooms served as residences and kivas used for ceremonial and clan-level ritual, although Fewkes (1902) shows that rooms also served clan and ritual purposes. Mobley-Tanaka (1997:437; see also footnote 32, p. 135) records that kivas in the historic period served as centers for the practice and maintenance of secret and sacred knowledge. The development of surface-level mealing rooms in Pueblo III has been linked to women's work. The more male-controlled ritual spaces (446), such as certain rooms and ceremonial kivas in the historic period, could also be reflected at Sand Canyon Pueblo. These could logically have been focused on towers (defensive and thus warrior-themed) and their associated rooms. The most obvious plants associated with historic kivas which have been associated with ceremony are documented by Hough (1897) for the Hopi: 1) *cübi*, the name given to skunkbush sumac (*Rhus trilobata* Nutt.)(twigs), 2) dried *sivwapi*, or rabbitbrush, translated as "yellow whip" (Fewkes 1896) is identified as *Bigelovia howardii*, a species of rabbitbrush now categorized as *Chrysothamnus* [USDA NRCS 2015]), 3) s*üóvi*, the name given to fourwing saltbush (*Atriplex canescens* James), and, 4) *tewi* or *teve*, the name given to greasewood (*Sarcobatus vermiculatus*

Torr.). *Teve* was acknowledged to be the dominant kiva fuel (Fewkes 1896).[92] At SCP the typical fuel material consists of juniper, pine and rose species types.

Hearth comparison 1: test trench kiva 400

Study sample FV6 and a comparison volume (CV6) were excavated from the hearth. Due to limited excavation, the kiva type is unknown (see chapter seven, page 194). The hearth is described as formal, circular, centrally located with trivet stones in place, suggesting its last use included cooking, as well as use for heat and light (CCAC 2004, Kivas, Structure 400). Originally built into subfloor deposits, it had a slab base on the south portion and a bedrock base on the north. It measured 58 cm in length, 57 cm in width, and 29 cm in depth and was filled with ash. The hearth contained a projectile point and an apparent "trivet" stone for cooking (CCAC 2004: Kivas, Structure 400). A few artifacts, pottery sherds and a portion of a slab metate were found in the test pit.

The new sample, FV6 (PD 1454, FS 9) measured between 875-1000 ml prior to processing. This sample produced approximately 44 ml of light fraction and I examined 8.7 ml using SAC subsampling. Only 1 ml of material was recovered in the 4.75 and 2.8 ml screens, the bulk of this sample consisted of extraneous microscopic sediment. Because the bulk of sediments persisted in the smallest light fraction screens I subsampled regardless of the overall volume being under the 50 ml SAC triggering volume. In an attempt to compensate I examined the total 1.4 mm screen contents. I compare my findings with evidence from the original analysis of an 870 ml flotation sample (CV6/"volume 1," PD 1454 FS 10) recovered from the same hearth. Total light fraction volume recorded for CV6 was 61 ml and 52 ml was examined.

Original findings: CV6

Juniperus charcoal and a scant amount of *Pinus* bark scales were identified.

New findings: FV6

Both *Juniperus* and *Pinus* charcoal was present as well as bark scales. A quantity of sedimentary fill and unidentifiable vitrified tissue and ash made up the contents of this sample.

[92] Fewkes (1896:20) notes that in historic times, the Hopi used the dried branches of shrubs, not specifically the wood. If the historic record reflects ancient use, I would expect to find evidence of twigs, leaves, flowers, buds etc., in kiva fires rather than simply wood remains. In addition, Hopi children were "whipped" with the pliable twigs of rabbitbrush during initiation ceremonies (unspecified by Hough)(the Hopi word for rabbitbrush, *sivwapi* come from *sikyañpu*, meaning yellow and *vwuvwapi*, meaning whip). A bright yellow pigment obtained from an infusion of rabbitbrush flowers mixed with a "chalky stone" was used for personal decoration on ceremonial occasions. Another species of *Bigelovia* (*douglasii stenophylla*)(rabbitbrush) is associated with the use of the branches and tips for medicinal purposes. *Atriplex*, too, is known to have pharmacological effects. These are explored in chapter eleven.

The hearth in kiva 400 was extensively used and contained "thoroughly combusted ash" (CCAC 2004, Kivas, Structure 400, Features) indicating that the hearth was not cleaned out after its last use. It's quite possible that a fire for light and heat was the final use. Considerations of timing of meals within a 24-hour period could explain the lack of remains. It is also possible that the final attack interrupted the use of this feature and burned out over time. No faunal remains were located in the hearth fill or the vicinity although the fill did contain a projectile point. No new information, other than the burning of pine wood was gained from the analysis of an additional volume for this hearth and the combination of juniper and pine wood is consistent in ubiquity and relative abundances of other thermal features across the site. There are two additional one-litre flotation samples unprocessed and archived if future analysis is considered. Data documented for this comparison can be found in Table E.6 (Appendix E).

Hearth comparison 2: kiva 517

The hearth in this kiva stopped being used prior to village depopulation (CCAC 2004, Kivas, Structure 517). It was only partially excavated. Dismantling of the roof beams and hearth deflector indicate that the materials were likely re-used elsewhere when the inhabitants of the residence left. The hearth had been reconfigured at some point with a new rim added during a re-plastering of the floor, the ash left in situ. The feature measured 70 cm in length, 73 cm in width (incomplete) and 23 cm in depth. Three strata were identified in the fill, the second stratum being a more compacted layer. The samples (sample FV7 and comparison sample, CV7) were taken from the third and lowermost stratum representing use prior to the remodeling event (CCAC 2004: Kivas, Structure 517). The plant remains recovered in these samples reflect earlier use of plants in and around the hearth, possibly in a time period that may reflect "normal" at Sand Canyon Pueblo. Very little in the way of transitional activities can be identified in block 500, although this may not apply to this kiva particularly, if it was used by a different residence group. I infer timing in the A.D. 1270s, prior to the final phase of occupation marked by violence, based on the remodeling event. Data for both samples are presented in Table E.7 (Appendix E).

New flotation sample, FV7 (PD 1481, FS 3), measured 850 ml before flotation and produced 60.5 ml of light fraction. I subsampled only the .71 and .25 mm portions. I examined all the content of the 1.4 mm screen because, unlike the previous hearth samples, this sample contained more plant remains and scanning the 1.4 ml screen content is fairly efficient. In total I examined 19.1 ml for the entire volume. My findings are compared to a previously analyzed 800 ml sample (CV7/"volume 1," PD 1482, FS 4) excavated from the same deposit and stratum. This sample yielded 59 ml of total light fraction and 52 ml was examined and I presume SAC subsampling was imposed.

Original findings: CV7

The sample contained evidence of *Juniperus* and *Amelanchier/Peraphyllum* charcoal and *Pinus* bark scales. Food remains are inferred from the identification of a *Cucurbita*-type (gourd/squash) seed, *Opuntia* seed fragments and *Physalis longifolia* seeds. An unknown seed is also noted.

New findings: FV7

The new sample contained *Juniperus osteosperma* twigs and scale leaves, *Juniperus* charcoal in similar quantities as the original volume, and *Pinus* bark scales. I identified the pine charcoal as *Pinus edulis* but did not observe any *Amelanchier/Peraphyllum* as recorded for the original volume although this sample contained *Artemisia tridentata* charcoal. The kiva was not burned after abandonment or as a result of the final warfare and this shrubby fuel material was not present as a result of shrubs introduced to burn the roof. I could find no evidence of domesticates. I note a seed coat similar in morphology to tumblemustard (*Sisybrium/Thelypodiopsis*-type) and unknown buds. An assessment of suggested interpretative values for both this and the new volume is outlined in Table 8.7.

Table 8.7 Suggested inference potential: hearth comparison 2 (charred remains).

Interpretive Category	Volume 1 (CV7)	New volume (FV7)	New taxa[a]
Foods			
Domesticates (FD)	*Cucurbita*	-	-
Wild resources, weedy (FW)	*Physalis longifolia*	-	-
Wild resources, nonweedy (FN)	*Opuntia*	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit	*Juniperus*	*Juniperus*	-
(FLN)	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Amelanchier/Peraphyllum*	-	-
	-	*Artemisia tridentata*	*Artemisia tridentata*
Zea mays cob remains (FLZ)	-	-	-
Tinder types (FLT)	*Pinus*	*Pinus*	-
	-	*Juniperus osteosperma*	*Juniperus osteosperma*
Other			
Other, ecological (OE)	*Opuntia* [fall?]	-	-
[seasonality]	*Physalis longifolia* [fall]	-	-
Other, unknown (OU)	-	*Sisymbrium/Thelyodiopsis* –type (cf)[b]	*Sisymbrium/Thelyodiopsis* –type (cf)[b]
Other, worked (OW)	-	-	-
Genera/species count	**6**	**4**	**4**
Inferred interpretative value	**8**	**6**	**4**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

[b] Compares favourably

The original sample provided evidence of both domesticated and wild nonweedy food resource types indicating that a final meal was prepared here and that the hearth was only minimally cleaned out, if at all, when the occupants left. Six taxa are identified in the original volume. Two seed types suggest season of use, placing the last use in the fall unless these represent stores. The seeds of common groundcherry provide evidence of the use of the fruit. Four new plants are identified in the second flotation sample (*J. osteosperma* and *P. edulis* are considered additional information). One species (*Artemisia tridentata*) is new for this feature. The typical fuel materials at Sand Canyon Pueblo are juniper, pine, and rose-species woods. Shrubs such as big sagebrush are most typically associated with roof fall. This matches the drying of such shrubs on kiva roofs as recorded in ethnographic records. The burn and fracture patterns of sagebrush probably contribute to its non-visibility. A good tinder material, sagebrush breaks up quickly because of its highly porous morphology and ring boundaries. As noted earlier, sagebrush is a pharmacologically active species and the presence of such material could indicate that its purpose was not related to strictly fuel Sagebrush is used as a fumigant or smudge.

The ethnobotanical record offers some interesting cultural connections with the *Sisymbrium/Thelyodiopsis* seed type identified in this sample. *Sisymbrium canescens* Nutt. is documented by both Fewkes (1896) and Hough (1897) as a culturally important species.[93] The Hopi name, *asa* (unknown meaning [Fewkes 1896]), or *a:ʹsa* (possibly having meaning connected to prairie dog [Whiting 1939:77]) applies to this species, the common name in contemporary usage is western tansy mustard. The plant was recorded as cooked, as greens or flavoring with meat and vegetables by the Hopi and being prized for its salty flavour (Whiting 1939:18-19). Tansy mustard is also a Hopi clan name (47). Stevenson (1915:86) documents the Zuni name *aiʹyaho* for *Sophia halictorum* Cockerell, now classified as *Descurainia* pinnata (Walter) Britton ssp. *hacitorum* (Cockerell) Detling (the common name is also western tansy mustard) and associated with the Zuni *Aiʹhaokwe* clan. Tansy mustard, then, has multiple uses, meanings, and associations in the historic period and is a new herb for the SCP record. Its clan significance could be related to its use in as an ingredient in pottery paint along with *Cleome* and for decorating ceremonial objects (26, 28).[94] It is a "gendered" species, associated with women's trade, and is interesting in connection with block 500, which is notable for its rare stone mortar.

[93] The botanical name, *Sisymbrium canescens* Nutt. is no longer used but is a synonym of *Descurainia pinnata* (Walter) Britton ssp. *pinnata* or *Sophia pinnata* (Walt.) Britton also known as western tansymustard (Whiting 1939:77; The Plant List 2013). This subspecies is not native to the four corner states although other subspecies known by the same common name are native. *Sophia pinnata*, *Sisymbrium sophia* and *Descurainia sophia* also appear to be associated with the same plant as identified by Fewkes (1896), Hough (1897) and Whiting (1939).

[94] Robbins et al. (1916:60) records a recipe for *Sophia* sp. (tansy mustard): "bundles of the plant, moistened, are steamed in a can in a pit or […] 'some people boil it, but steaming thus is the best way, so that it will melt smooth.' A quantity of liquid is then squeezed out, and the mass, which remains is molded into a cake and, wrapped in corn husk, is stored for winter use. It is an article of trade between women. For use, a small piece is broken off, dipped in water, and rubbed down on a stone palette with a hard mineral paint called *icupen* (&w, stone; pej), blackness."

The identification of pine charcoal as pinyon is new to SCP. The only previous evidence of pinyon is documented in the recovery of some cone scales (Adams et al. 2007; Table 4). It is possible that the pine identified in past years was pinyon although the characteristic resin canals can often be seen even in the smallest fragments. The use of pinyon pine confirms that the plant was available and used routinely. The value of the second sample (FV7) resides in the identification of this species and *Artemisia tridentata* for enhanced interpretation of wood choices and/or availability. The possibility that small seeds such as tansy mustard might be missed through subsampling is likely. No additional flotation samples were excavated from this deposit and the two samples evaluated here are presumed to represent the entire contents of the hearth.

<u>Hearth comparison 3: test trench kiva 601</u>

This well-used formally constructed hearth was found in the partial excavation of a kiva of unknown type (kiva 601; chapter seven p. 199). A quantity of ash was still present on excavation. The test trench exposed only a portion of the kiva floor and approximately three-quarters of the hearth was excavated. A tree-ring date of A.D. 1255 may indicate the date of construction of the kiva, making it an early building on the site (CCAC 2004: Kivas, Structure 601). The hearth was dug into floor deposits and lined with vertical stones, some still had plaster on the tops. It measured 59 cm in length (incomplete), 53 cm in width and 23 cm in depth and had been used extensively. It contained trivet stones supporting an interpretation of cooking as a last use. A vegetal sample collected from roof fall yielded *Juniperus* and *Pinus* charcoal. The scant remains of burned black turkey bones, the body of a pottery jar and the rim of a bowl were found in the trench fill (see CCAC 2004: Structure 601, Artifacts, Animal Bone Analysis Summary). The timing of disuse is difficult to assess, although a nearby kiva (structure 602) was clearly abandoned in a violent context (CCAC 2004 Kivas, Structure 602). For that reason, I suspect that the final use of the hearth in kiva 601 likely also occurred in the last day or days prior to the warfare event. No post-abandonment activity was noted.

New flotation sample “FV8” (PD 1530, FS 2) measured 1000 ml prior to processing and produced 28.5 ml of light fraction. I examined 19.4 ml. Over half of the light fraction volume was recovered in the smallest screens sizes and I subsampled using the SAC standards for the .71 and .25 mm portions and examined all 1.4 mm portion in an attempt to compensate somewhat. I compare sample FV8 to a 750 ml flotation sample, now labeled CV8 (“volume 1,” PD 1531, FS 2), from the same hearth and stratum. This volume produced 58 ml of light fraction and 47 ml was examined.

Original findings: CV8

This sample contained *Juniperus* charcoal interpreted to represent fuel wood. *Zea mays* may also have been used as fuel based on the identification of a cupule. Two *Opuntia* seeds and an unknown, uncharred bone are also documented.

New findings: FV8

This sample contained *Juniperus* and *Pinus edulis* charcoal. No maize or other identifiable remains were observed. A variety of uncharred plant materials suggest that there was disturbance in the fill (see Table E.8, Appendix E). These materials consist of uncharred cheno-am, grass (floret), and *Artemisia tridentata* (leaf) and an uncharred *Pupoides* sp. gastropod (land snail)(Manuel Palacios-Fest, personal communication, June 2010).[95] Muir (2007) also identified a specimen of Gastropoda for the faunal record of SCP but not, as far as I am aware, in this context. Inference values are suggested for this and the new sample in Table 8.8.

Table 8.8 Suggested inference potential: hearth comparison 3 (charred remains unless otherwise specified).

Interpretive Category	Volume 1 (CV8)	New volume (FV8)	New taxa[a]
Foods			
Domesticates (FD)	-	-	-
Wild resources, weedy (FW)	-	-	-
Wild resources, nonweedy (FN)	*Opuntia*	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit	*Juniperus*	*Juniperus*	-
(FLN)	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	-	-	-
Zea mays cob remains (FLZ)	*Zea mays*	-	-
Tinder types (FLT)	-	-	-
Other			
Other, ecological (OE) [seasonality]	*Opuntia* [fall?]	-	-
Other, unknown (OU)	-	*Pupoides* sp.	*Pupoides* sp.
Other, worked (OW)	-	(uncharred)(cf)[b]	(uncharred)(cf)[b]
Genera/species count	**3**	**3**	**2**
Inferred interpretative value	**4**	**3**	**2**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

[b] Compares favourably.

[95] A similar land snail was found along with several gastropods documented and photographed for the Koster site, a 7,000-year-old site in Illinois excavated by Struever and Holton, monograph published in 1979). Photographs were provided to Dr. Palacios-Fest for identification of Sand Canyon Pueblo gastropods found in flotation samples. This snail is minute in size and common to grassland habitats (Descriptions in Appendix C; photographs D.156 and D.158, Appendix D).

The quantity of ash recorded by the original excavators suggests that a substantial fire was built in this hearth although little evidence of identifiable material remained. The recovered contents of the two flotation samples paint a bleak picture of little diversity in fuel types and only a nonweedy, difficult to harvest seed. The historic use of *Opuntia* and finely ground maize are typical Pueblo III staples. Excavator notes record some chipped stone and a couple of burned turkey bone fragments in the exposed fill of the kiva (CCAC 2004, Kivas, Structure 601, Artifact Inventory, Animal Bone Analysis Summary).

No additional flotation samples were collected and the value of the additional sample lies in the identification of pinyon pine and the apparent absence of plant remains is a typical feature of cleaned hearths at SCP.

Hearth comparison 4: kiva 1010

Two samples are compared for this kiva hearth described in chapter seven (p. 211). The original hearth measured 80 cm in length and 34 cm in width at the lower surface level, 40 cm pre-remodeling. Remodeled length is measured at 54 cm and width at 35 cm with an inferred depth of 16 cm. The sediments from both samples evaluated here came from the remodeled hearth, the contents representing a final meal or fire. The faunal record indicates that the burnt bones of cottontail and some unidentifiable nonhuman bones were left *in situ*. A turkey bone awl was present in the kiva fill (CCAC 2004: Kivas, Structure 1010, Artifacts, Animal Bone Analysis Summary). The kiva was abandoned as a result of the catastrophic events of circa A.D. 1277 (CCAC 2004, Kivas, Structure 1010, Features).

New flotation sample, FV9 (PD 1432, FS 14), measured 1000 ml before processing and produced 28.5 ml of light fraction. Because of the concentration of sediments in the smallest screen sizes I subsampled the .71 and .25 mm portions and examined the entire contents of 1.4 mm screen for a total of 21.9 ml examined for the sample. The findings are compared to a previously examined 1000 ml sample from the same context and surface, now labeled CV9/"volume 1," (PD 1432, FS 13). This sample yielded only 13 ml of light fraction and all was examined. Sample data are recorded in Table E.8 (Appendix E).

Original findings: CV9

This sample of minimal light fraction contained no evidence of domesticate or wild plant resources other than *Juniperus* charcoal and several unidentifiable buds.

New findings: FV9

Fuel types and food resources consisted of *Juniperus* and *Pinus* charcoal and a relative abundance of *Juniperus osteosperma* twigs and scale leaves (Table E.9, Appendix E). I identified both *Amaranthus* (pigweed) and *Chenopodium* (goosefoot) seeds. An *Oryzopsis hymenoides* floret and caryopsis and some unknown buds were also recovered giving spring or summer as the final season of use of the feature Inference potential is suggest in Table 8.9 (over).

Table 8.9 Suggested inference potential: hearth comparison 4 (charred remains).

Interpretive Category	Volume 1 (CV9)	New volume (FV9)	New taxa[a]
Foods			
Domesticates (FD)	-	-	-
Wild resources, weedy (FW)	-	*Amaranthus*	*Amaranthus*
	-	*Chenopodium*	*Chenopodium*
	-	*Oryzopsis hymenoides*	*Oryzopsis hymenoides*
Wild resources, nonweedy (FN)	-	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
Shrubby growth habit (FLS)	-	-	-
Zea mays cob remains (FLZ)	-	-	-
Tinder types (FLT)	-	*Juniperus osteosperma*	*Juniperus osteosperma*
	-	*Pinus*	*Pinus*
Other			
Other, ecological (OE) [seasonality]	-	*Amaranthus* [summer]	*Amaranthus* [summer]
	-	*Chenopodium* [summer]	*Chenopodium* [summer]
	-	*Oryzopsis hymenoides* [spring/summer]	*Oryzopsis hymenoides* [spring/summer]
Other, unknown (OU)	Buds	Buds	-
Other, worked (OW)	-	-	-
Genera/species count	**1**	**5-6**	**5**
Inferred interpretative value	**1-2**	**10**	**8**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

The original sample suggests a well-cleaned hearth, the sample containing little in the way of plant remains, the bulk of the material consisting of sediment that washed away during processing. With analysis of an additional sample a different interpretation is possible for the contents of this hearth. This sample yielded seeds of weedy annuals typically associated with disturbed environments such as building sites or agricultural fields. Most typically identified as “cheno-am,” pigweed and goosefoot identified in the second sample were likely recognized as different in ancient times as they have been in the historic period. These remains either place use of the feature in the summer months or represent stored seeds if the hearth was used in the fall. An Indian ricegrass caryopsis situates deposition from early spring until June in the Sand Canyon area (see Adams et al. 2007: Table 17). The presence of unidentified buds also supports this assessment. The lack of maize in both samples could be interpreted to be the result of lack of domesticated resources, a meager meal, a meal interrupted, the timing in the day prior to food preparation, or simply the natural outcome of seasonality and a pre-harvest deposition. An alternative explanation may be that corn meal or highly processed maize was used here consistent with what we know of the Pueblo III diet, the seeds of wild plants introduced as part of the recipe.

The additional sample provides five new species and an estimated eight new inference values for the interpretation of this hearth. The analysis of this hearth is incomplete for several reasons, including the unknown effects of subsampling and an additional unexamined sample available for future analysis. Reviewing the faunal record for this hearth, cottontail bone was present in the fill. Cottontail and wild plants made up at least some part of the last meal (CCAC 2004, Kivas, Structure 1010, Animal Bone Analysis). The significance of the seed types in a hearth context is important for a number of reasons that I explore in the next section since cheno-am as a research category has implications for specificity in interpretation.

“Cheno-am:” ethnographic analogy and trauma—archaeological evidence of durability and change

The importance of cheno-am as an identification category has much to offer encompassing as it does, two different plants that while similar in appearance were recognized historically as different. Wary of overreaching reasonable interpretation, Trigger (1989:408) cautions of a “temptation to leap to conclusions ... [p]articularly if interpretations correspond with common sense and the values held by the investigator...” a balance is struck however, through recognition that human perception or cognition (or perhaps more accurately, “cognitions”) encompass perceptions, sensations, and intuitions signifying a range of values to the individual and the collective, today as in the past. Crumley (1999:270-271) articulates far more succinctly than I can that we aim to recapture some sense of the cognitive experience:

> Now [today] ... archaeological theory is dominated by the debate over not *if*, but *how* mind is recoverable. It is now recognized that humans both affect and are affected by the material world; furthermore, mental activity can be recorded in material remains, and material structures and conditions affect perception.
> Culture acts like a “carrier wave,” transmitting information across time and space. Even when the connection between memory and meaning is severed (as when a ritual is retained but its meaning lost), information can still be delivered to future generations. The most effective carriers of social memory are landscape elements that have both practical utility and cosmic meaning, such as caves, springs, or gardens. Such elements offer a range of thoughts and behaviors and the richer the meanings that such concepts evoke, the greater likelihood that diverse information bundled around that concept will be transmitted.

The categories of “wild” and “domesticated” plants would not have been separated as fundamentally different or that such things would be culturally significant in the past. “Cheno-am” (either *Chenopodium* or *Amaranthus*), a seed similar in morphology and growth habit, held value beyond simply a wild small seed as evidenced in Basketmaker through the Pueblo periods (see Adams and Paterson 2011). In the historic period the seeds were articulated as valuable as maize. This simple linguistic research short-form, “cheno-am,” also speaks to a critical anthropology and archaeology.

All “used” plants are part of a human ecosystem that works under the constraints of culture and environment. Not only ecological, this is environment in the broadest terms, the mental, manipulated, and experienced environment, a response to life’s impositions that at a basic level consists of food, fuel, heat, light, and sociability. Abel and Stepp (2003) argue that, “the prehistoric ‘environment’ must be viewed not as a backdrop but as a ‘moving target’ negotiated incessantly with humans and with other processes at both larger and smaller scales.” Cultural “scripts,” how cultures see and behave in the world, are part of that negotiation (Goddard 2006; Wierzbicka 1994, 2015), requiring little deliberate effort when one becomes expert, hardwired in the individual brain and reiterated through cultural practice and tradition. The signature can be seen in the ideas and subsequent development of technologies in response to a cultural logic under the imposition of particular needs (Wierzbicka 2015), imposing cultural *norms*, the ultimate of neurologically hardwired scripts. Language is central to maintaining such traditions and contributes to their persistence through time. Whiteley’s (1998) “compact phrase” that are Hopi words and naming traditions, are examples. Like the name-images and “densely laconic narratives [embedded] in Hopi names” (113-114), names/words/things hint at a *particular* set of behaviours around particular ideas and realities and reinforces these notions by animating a descriptive and “aesthetic force” of embedded cultural values. This is the case with something as simplistic as “cheno-am,” a contemporary identification category we associate with food procurement but one that in the past was associated within acceptable cultural behaviour and entrenched cultural scripts.

The residents of Sand Canyon lived under the threat of both ecological uncertainty and cultural trauma that was long-standing, its evidence built into the knowledge of plants on the landscape and the architecture of the village. The people’s resilience to rapidly developing concerns included defensive structures that held a desire to achieve a better “normality” through protective strategies. The final violent events would be a local and deeply personal trauma for Sand Canyon residents, part of a wider cultural catastrophe of the Mesa Verde region in the late 13th century. It was on a scale that was different then previous threats that prompted construction and catastrophic enough to shatter pre-existing systems. These are people who had been responding to considerable challenges, drought, and trauma for centuries. The events of the Mesa Verde era demanded a new resilience, one that appears more dramatic than the collapse of the earlier Chaco Canyon complex where continued threads of building styles and socio-political organization can be seen in such features as D-shaped buildings. The question becomes, what changes for people in response to trauma, and what does not? A specific question for archaeobotanists is, does traditional cuisine change dramatically as a result of the passage of time, drought, trauma, and social stress and can the historic record shed light on past action with plants? Certainly there is clear evidence that corn was managed archaeologically and historically with great ingenuity in response to the very real stressors that would have been, and continues to be, farming in this region. Would traditional healing practices and sacred knowledge change dramatically as well?

Trauma as an individual experience biologically rewires the human brain (Van der Kolk 2006). Such events as war and terror in the ancient past can be expected to impose similar psychological effects that are mirrored in the social and personal costs experienced by trauma victims today. This is particularly true of war zones where massive disruptions in how we perceive our once "normal" worlds are defining features. Reinhard (2006:261) confirms that "they [Ancestral Pueblo] had a level of violence typical of most human populations—present but not excessive." Our global trauma reflects similar presence, an increasingly present backdrop. "Much of coping [as a result of trauma] occurs in plain sight, in efforts to reclaim and enact everyday routines and practices" (Hollan 2013 in Good 2013). Ritualized behaviour and reinforced cultural metaphor are life-affirming strategies for coping particularly in cases of extreme violence or "social ruptures" (Good 2013). The gradual acceptance that violence can be expected, the "normal" for Sand Canyon, likely caused scattered migrations out of the region but it did not terminate residency entirely until around A.D. 1277 when something beyond acceptably "normal" occurred. Time-tested strategies clearly failed, specifically they failed to protect people. In this respect their deeply embedded cultural/behavioural scripts for defense also failed. Sand Canyon and Mesa Verde survivors made a choice to act and act differently in response. New approaches and new spaces are methods to begin to re-write trauma and re-wire neurobiology (Good 2013; Herman 1997). One component of effectively dealing with the emotional toll of violence is to move away and to embrace and reinforce through action life-sustaining cultural values (Herman 1997). Effectively embracing the notion of "world as it should not be, world as it should become" (Hieb 1972:176-180; see also footnote 54, p. 182 here).Changing surroundings provides a starting point for a new and productive way of approaching problems by circumventing some of the relived anguish associated with emotional triggers: the sights, sounds, places and spaces revisited in a traumatic emotional loop in real time. The Mesa Verde area had became intolerable, perhaps not so much ecologically, but emotionally, so much so that normal behaviours could no longer be sustained there. The burning of kiva roofs and the presence of ephemeral fires may indicate that revisiting and perhaps some closure was achieved. This version of "making the world work," can be seen in the earlier short-term strategies of blocking doorways and longer-term building of towers. When all else fails, Pueblo identity was compelled to re-establish in a new landscape with a new architecture. Gone are the towers. What we might be seeing at the turn of the 13th century is an act of "resilience thinking," that today is founded in ecological theories such as MacArthur and Wilson's (1967) theory of equilibrium applied to psychology, which in effect, is fundamentally *a resilience under changing conditions* (Curtin and Parker 2014). Illustrated succinctly by Holling (1973 in Curtin and Parker 2014:915), one can see the pattern played out in the experience and the reconfiguration of a culture:

> The very process of trying to maintain a system within a narrow range of limits may actually increase the likelihood of its collapse. In contrast to stability-driven approaches that seek to control systems within acceptable human-defined bounds, resilience is persistence driven and focuses on the emergence of longevity-inducing behaviors that maintain a system while withstanding change. Resilience-based management begins with an assumption of insufficient knowledge ("our ignorance" of the complex dynamics of natural systems) and the guiding principle to expect the unexpected in how systems respond to change.

The Ancestral Puebloans apparently resolved their collective trauma not through "Mesa Verde" life choices but through a new script, through the behaviours that reaffirmed values and were mythologized as helpful, the result durable. Their approach to the "Pueblo III collapse" might be seen in a new architecture elsewhere, the appearance or archaeological visibility of the Katsina Cult associated with Pueblo IV (A.D. 1300 – A.D. 1600), a "post-Mesa Verde" archaeological era. Similar to the original Sand Canyon Pueblo identity so marked by public architecture, this "new" resilience refocuses attention on moral imperatives embedded in what were and are traditionally valued ideas and things, things that for reasons we cannot state with certainty, shifted to "disorder" in the last years of the Sand Canyon Pueblo occupation. Leaving Mesa Verde may have been, up to that point, the ultimate resilience experience for Hopi, the "Peaceful People" of the historic ethnographic record (Hough 1897:34). In the centuries that followed emphasis on social connections, welcoming and imposing obligations for coherence, were achieved by embedding a deep empathy for and connection to, the good life—being Hopi (or Zuni, or "Pueblo") through ritual, song, dance, and the creation, recreation, or re-emphasis of a system of clans and societies to facilitate and expand moral obligations as we see in the historic and contemporary society. Ancestral Pueblo may indeed be the first "scientists" to address traumatic stress through acts and action, strategies that have taken Western science to this decade to see the same.

On-going debates over the reasons for the abandonment of much of the ancient Pueblo world often return to the initiation of the Katsina cult and its associated ceremony, occurring as it appears in the proto-historic period of the Pueblo sequence. The mass depopulation of large parts of the American Southwest, including Mesa Verde signals the beginning of "Pueblo IV" and ends with

Spanish contact in the year A.D. 1539 (Adams and Duff 2004:3). Archaeological changes that we see in village plan, pottery production, decoration, and evidence of Katsina iconography painted in rock art and on and in ceramics, developed into a ritual system in the late 1200s (Adams and Duff 2004: 4; Duff 2002:61). The Puebloan Fourth world did not arise suddenly in the archaeological era "Pueblo IV," it came before. This system had its roots in deep time seen in Basketmaker, the pithouse-turned-kiva, the burial of the dead in particular places, and compelling markers of identity that in some cases are plants or the artifacts associated with them (Adams et al. 2011; Adams and Paterson 2011). The Hopi and Zuni in "ethnographic" times forming "coherent cultural groupings with strong social identities"(Duff 2002: 61) where clans and existential powers clearly combine. Forced through trauma to rewrite their history, The Pueblos did not do so by changing fundamentals but rather in how they thought about identity, what they valued, and how the good could endure.

How are plants situated within this cognitive system? Stevenson (1915:63) writes of the historic Zuni's relationship with plants and ceremony:

> The life of the Zuñi [sic] is a prolonged ceremony from birth to death, of which plant life forms a conspicuous feature; but plants are revered apart from their association with ceremony and the curing of the sick. The Zuñi have a passion for the beautiful in nature.

With the possible exception of pine trees that may or may not have been overharvested, the plant communities of the Southwest remained largely consistent on the landscape, adapted to arid environments, strategies for managing subsistence the same or similar enough. "Small seeds" are still small seeds. Some may no longer have been used by the mid 1900s but still understood to have been important, belonging to the grandfathers, or the ancient ancestors (Cushing 1920). The reality is wild resources are not so very different "200 miles" (approximately 320 km) away from Sand Canyon, 200 miles a mere jaunt for the Hopi (Hough 1897). Long-standing traditions, ecological management and the knowledge that preceded it would not be abandoned so quickly because that was not necessary to re-establish a new cuisine in the Southwest, at least not until the Spanish incursion, that in addition to a variety of new catastrophic and appalling disruptions, added a few new and interesting non-native foods. "While the [Spanish] priests made little impression on the soul of the Hopi, they did reorganize their diet" states Whiting (1939:9), but to what degree? Favorite foods, standards of cooking, the use of wood for fires and building materials followed entrenched behavioural scripts, ones that sustained. If there were shifts, the scripts would be ceremonial, the plants given as names to children and embraced as the names of clans and associated groups providing the security of what was and now is, a cultural identity, one inextricably in relationship with plants. Elaborate celebration ensured the persistence of, or return to a good life and a peaceful one because that was its intent—to rebalance the world according to Pueblo values. The Hopi and Zuni plant world, the relationship with sustenance and the soul as something inseparable, becoming even more sacred, or more visible, through behaviour within a pre-existing system. Although sociocultural change is identified with an iconography painted with care on vessels, the vessels themselves still serve the purpose of being containers that hold precious things, the familiar foods, medicines, beverages, and dyes. Similar to Ford's (1980) colours of survival (the selection of many colour maize for specific cultural purposes we see in historic practice), the new colour of the Pueblo world was not so dramatically replaced by something entirely different but retooled through celebration or made more visible by the process and time. The fundamentals unchanged, the expression heightened and made congruent through a process of four stages of what contemporary psychiatry conceptualizes as trauma resolution: 1) impact, 2) retreat, 3) acknowledgement, and 4) reconstruction (Herman 1997; Lande et al. 2010:43). In Pueblo history we see this transformation through art and performance, embracing a cultural form of generativity, one that may be less visible in earlier periods.

The loss of traditional ethnobotanical knowledge and cultural change is the result of contemporary land displacement (Saynes-Vásquez et al. 2013; Turner 1988) but did this occur after Mesa Verde? It was a displacement within a well-entrenched strategy of coping in a landscape that was well known. If there is doubt that too much time has past between the ancient and the historical to assume connections, human response to trauma attests to the fact that time does not always heal, although "moving away" can help reconfigure events into something conceptually cohesive. Herman (1997:1) opens her monograph on trauma and recovery with the words: "The ordinary response to atrocities is to banish them from consciousness. Certain violations of the social compact are too terrible to utter aloud: this is the meaning of the word *unspeakable*"(1). There is clearly an ultimate atrocity in the Mesa Verde "era" of Pueblo pre-history where a reconfiguration of "establishing community" occurs.[96] It is highly unlikely that a shift in diet occurred or played any role at all in this transformation we categorize as "Pueblo IV." The same can be said of ethnographic and ethno-botanical records that contain threads of ancient adaptations. In traditional societies these can be relied on as effective and robust connections with earlier times. The interpretation of ancient remains resituated to be more reflective of this lived experience through local theory and a reconfigured question that explores potentials, a direct historical approach that includes context writ large and the realities of human cognition: *what might the "recipe" of plant remains from the hearth in kiva 1010*

[96] The "abandoned" bear of block 100, when viewed from the perspective of common human trauma hints that the people associated with this artifact, if representing a political entity, were also abandoned. The headless bear of the Dolores River drainage (Cole 2009:114, figure 55d: Uncompahgre Style, site 5MN1186) clearly indicates a conflicting message of the power of the bear. The *Patsavu* ceremony of Orayvi as detailed by Whiteley (1998) combined with the traumatic rewriting of mythic atrocities suggests parallels. The bear turning away the Badger clan and later acknowledging the error by repeatedly petitioning them to return is striking in this context.

signify if this was a historic feature in a context of, or without, direct trauma? And, how might trauma (or method), impact the answer? "Cheno-am" provides an example of stability.

The Hopi recognized as many as five species of *Amaranthus* (pigweed species) in the historic period, one distinguished in two ways as *komo* and *komótoshu*, for making red dye and historically documented as introduced by the Spanish or gained through trade from Mexican villages (Hough 1897). The terminology is different when species of the plant are recognized as used in "ancient" times: *posíüh, pociüh,* or *po:'siowu*, all applied to the non-native species: *Amaranthus blitoides*-type (common name: mat amaranth), *po:'siowu* used for its leaves, the others, prized for their seeds. *Wi'wa/wi:'wa*, known as ancient Hopi food, is identified as *Amaranthus* (*A. torreyi* [A. Gray] Benth. ex S. Watson and *A. acanthochiton* Sauer [common name: Torrey's amaranthus]). *Wi'wa* is documented as hanging in "every house," (Whiting 1939:74). Most likely used for its dried leaves (or why else hang it?), its seeds would litter the floors and be wasted through this method of storing, thus it was the leaves that were the object of storing. The descriptions of various tools and a process for collecting seeds indicate that the leaves and seeds were used and collected differently. There were collection activities associated with timing in the year: the seeds ready for harvest in the summer, the most tender and desirable leaves available earlier in the year. Stevenson (1915:65) records *Amaranthus* as a plant brought from the underworld by the rain priests (Zuni), who "scattered them over the earth." The seeds in this case are also known by different Zuni names. The leaves are identified with red amaranth, also designated an introduced species (*A. paniculatus* L./*A. hybridus* L. var. cruentus)(USDA NRCS 2015) and known as *i'shilowa yäl'tokia* "red face paint," or *ku'shutsi* "many seeds," ground with corn to mae black corn meal (Stevenson 1915:65) or used as rouge or for colouring *piki* bread (83, 87)(Table 8.10, over). *Chenopodium* uses are noted in Table 8.11 (p. 284).

Table 8.10 The cheno-am example: Hopi and Zuni historic use of *Amaranthus* from four historic sources:

Indigenous name	Scientific name[a]	Common name[a]	Source	Ethnographic use
Hopi				
Kómo (Hopi)	*Amaranthus* sp.	pigweed unspecified	Fewkes 1897	cultivated in terrace gardens around the springs. Used to dye *piki* red (39).
Komo (Hopi)	*A.paniculatus* [accepted name *Amaranthus cruentus* L.)	red amaranth	Hough 1897 Whiting 1939	designated an introduced species (USDA NRCS 2015), the seeds were obtained from the Spanish or Mexican villages. An infusion of the plant makes red dye for *piki* bread used in "katcina exhibitions" (Hough 189718). Whiting (1939:12, 74) records that the Hopi cultivated this species.
Komótoshu (Hopi)	"*Amaranthus palmeri* Watson (?)"	pigweed/ carelessweed	Fewkes 1897 Hough 1897	*A. palmeri* is a native species to the lower 48 States (USDA NRCS 2015). The seeds are used to make a red dye for *piki* bread "consumed during the kachina dances"(Fewkes 1897:39; Hough 1897:39).
Posíüh (Hopi)	*A. blitoides* Watson	mat amaranth	Fewkes 1897	designated an introduced species (USDA NRCS 2015), the seeds formerly used as food (Fewkes 1897:38).
Pociüh (Hopi) also known as *poshíotosü*	*A. blitoides*	mat amaranth	Hough 1897	Designated an introduced species (USDA NRCS 2015) the seeds were prized in past times for food. *Poshíotosü* is documented as "also eaten by sheep" (Hough 1897:18, 40)
Po:'siowu (Hopi)	*A. blitoides* S. Wats.	pigweed	Whiting 1939:74	designated an introduced species (USDA NRCS 2015) and "a common weed" cooked for greens and the seeds eaten. *Posi* means "seed"(74)
Wiwa (from *wiawai*, "to stumble")(Hopi)	*A. torreyi* [now *A.torreyi* (A. Gray) Benth. ex S. Watson]	Torrey's amaranthus	Hough 1897	a native species to Arizona (USDA NRCS 2015), the Hopi name is recorded as reflecting the procumbent stems which trip up passersby. The leaves were boiled and eaten with meat (Hough 1897:18)
Wiwa [Hough] *Wi:'wa* [Whiting](Hopi)	*Acanthochiton wrightii* Torr. [now classified as *Amaranthus acanthochiton* Sauer]	greenstripe	Hough 1897 Whiting 1939	a native species to Arizona, Texas and Utah (USDA, NRCS 2015), the plant is categorized as "a common weed resembling *Amaranthus*," gathered, strung in long bunches and hang "in early every house." (Whiting 1939:74) The plant is known as ancient Hopi food that they recount "warded off famine a number of times, springing up as it does before the corn is filled" (Hough 1897:37)
Zuni				
Ku'shutsi "many seeds" (Zuni)	*Amaranthus blitoides* S. Wats.	pigweed, mat amaranth, "tumble-weed"	Stevenson 1915	designated an introduced species (USDA, NRSC 2015), Zuni history identifies *ku'shutsi* as the plant brought from the undermost world of the rain priests who scattered them over the earth. Originally the seeds were eaten raw but after the Zuni were given corn, they were ground with black corn meal, mixed with water steamed in meal cakes (Stevenson 1915: 65)
I'shilowa yäl'tokia "red face paint" (Zuni)	*A.hybridus paniculatus* (L.) Uline & Bray [a synonym of *A. cruentus* L.]	red amaranth "purple amaranth"	Stevenson 1915	an introduced species (USDA, NRCS 2015) the leaves and flowers are crushed and moistened and rubbed on the cheeks as a rouge (83)
As above	As above	"pigweed"	Stevenson 1915	"the feathery part" of the plant is cultivated by Zuni women, ground into a fine meal and used to colour *he'we* (wafer) bread red. "The *he'we* is carried by personators of anthropic gods and thrown by them to the populace between dances"(87).

Notes:

[a] Scientific and common names from USDA, NRCS (2014) unless indicated otherwise or in quotation marks.

[b] The Plant List (2013)

Table 8.11 The cheno-am example: Hopi and Zuni historic use of *Chenopodium* from four historic sources.

Indigenous name	Scientific name[a]	Common name[a]	Source	Ethnographic use
Hopi				
Cirswa “from *cisrotañwa* …a liquid trickling down a vertical surface”(Hopi)	*C. album* [*Chenopodium album* L.]	lambsquarters	Fewkes 1896	Two species are native to Colorado, *C. album* var. *missouriense* (Missouri lambsquarters) and *C. album* var. *stratum* (lateflowering goosefoot) (USDA NRCS 2015). The leaves were boiled and eaten with fat. The stalk has vertical streaks of red color, which may explain the meaning of the Hopi word (Fewkes 1896:18).
Sü’rswa	*C. album* L.	lambsquarters	Hough 1987	leaves are boiled and eaten with fat (Hough 1987:38).
Si’swa also known as *h_3h_3’la*	*C. album* L	lambsquarters	Whiting 1939	*Chenopodium* spp. is an “occasional weed in the Hopi country”(Whiting 1939:73) but boiled and eaten with other foods (unspecified). It is packed around the fruits of *Yucca angustissima* according to one informant, when baked in earth ovens (73).
Kütüki “a syncopation of terms that mean “corn speaks,” for popcorn (Fewkes 1896) *Kotókí* (Hough 1897)	*C. cornutum* [*Chenopodium cornutum* (Torr.) Benth. & Hook. ex S. Watson][b] also catalogued as *C. graveolens* Willd.(Stone 2014)[c]	goosefoot, unspecified[b] fetid goosefoot[c]	Fewkes 1896 Hough 1987	noted as both a native and introduced species (USDA NRCS 2015), “this ‘popcorn-plant’ is so named because “it flings its ripe seeds abroad like decrepitating corn flying out of a vessel held over a hot fire.” Ground seeds are mixed with corn meal to make *somipiki*, “small dumplings wrapped in corn husk and tied with a shred of yucca”(18). Also as an emetic and for the making of gold/green dyes using from the whole plant (Stone 2004).
Ha’techi “strong odor leaf”	*C. cornutum* Benth. & Hook	goosefoot unspecified	Stevenson 1915	The whole plant is used as a remedy for headache by steeping it in water and inhaling the vapor. “All fraternities own this remedy” (Stevenson 1915:45).
Wupa tübhü (“*wapa”* meaning “long”)(Hopi)	*C. fremontii* [*C. fremontii* S. Watson]	Fremont’s goosefoot	Fewkes 1896	native to the lower 48 States and Canada (USDA NRCS 2015), the plant is recorded as used, no additional detail (Fewkes 1896:18).
Tcatcak tübhü (tcatcak is plural for “little”)	*C. leptophyllum* [*C. leptophyllum* (Moq.) Nutt. ex S. Watson, also known as *C. album* L. var. *leptophyllum* Moq.]	narrowleaf goosefoot	Fewkes 1896	native to the lower 48 states and Canada (USDA NRCS 2015) and recorded as used. “The seeds are minute,” with no other detail (Fewkes 1896:18).
Zuni				
Suthl’-to-k’ia (Zuni)	*Chenopodium*, Unspecified	goosefoot unspecified	Cushing 1920	“food of the ancients” and harvested with a closely-woven large, shallow tray placed near each plant and “energetically slapped with a fan or scoop.” “Probably the richest and most delicious ever known either to the ancient or modern Zuñi[sic] and its disuse as a source of food must undoubtedly be attributed rather to the difficulty attending its production than to any lack of quality” (Cushing 1920: 244-245).
Mi’-ta-li-k’o “father-in-law of corn” (Zuni)	“blue-leafed but otherwise resembling” *chenopodium*	?	Cushing 1920	described under “food of the ancients.” Cushing records the name as “archaic,” and the plant gathered in a similar manner to *suthl’-to-k’ia* (1920:245).

Notes:

[a] Scientific and common names from USDA, NRCS (2014) unless indicated otherwise or in quotation marks.

[b] The Plant List (2013)

[c] Stone 2004

The same categorizations apply to *Chenopodium* (Table 8.11, previous page). The Hopi recognized at least four species of *Chenopodium*: *Chenopodium album* (common name: lambsquarters) native to Colorado is recorded as *cirswa, sü'rswa,* and *si'swa,* the spelling presumably adapted by the various ethnographers. Use of *C. album* appears to be limited to its leaves. *Kütüki*, (*C. cornumtum* (Torr.) Benth. & Hook. ex S. Watson/*C. graveolens* Willd. [common name: Fetid goosefoot]) is translated as "corn speaks," named for its musical qualities because the seeds sound like popping corn when heated. Its seeds were used in the making of bread (note the similarity of Hopi *kütüki* and Zuni *ku'shutsi* for *Amaranthus* above). The leaves, "fetid" and strong smelling were also used historically for medicines, emetics and dyes (Stone 2004). The Zuni also used goosefoot in the ancient past, one seemingly known by "the archaic name," *mi'-ta-li-k'o* or "father-in-law" of corn (Cushing 1920:245). The use of *Chenopodium* as a kind of medicine for intestinal parasites as demonstrated by Reinhard et al. (1985) may be indistinguishable in early ethnographic records because of its medicinal attributes were presumably owned by particularly knowledgeable people and not widely shared.

<u>Hearth comparison 4: kiva 1010 continued.</u>

Cheno-am in the context of kiva 1010, as a "latest," or last days occupation of the village, gives us a meal that included cheno-am seeds and Indian ricegrass grains. Seeds in a hearth are unlikely to be the result of hanging fresh bundles of leaves for greens from roof rafters because fresh plants are typically gathered prior to seeding (the seeds too important to waste). An alternative explanation for seed presence might be that the seeds were cooked and used in combination with finely ground corn if historical records hint at an earlier cheno-am "small seeds" cuisine. The setting of the meal within a kiva associated with domestic activities may reflect the tradition of preparing ground meal of corn and other seeds in rooms, the cooking of such meals in the kiva itself. Cushing (1920:638-639) notes that corn was ground in separate rooms based on much older and "ancient" records of behaviour with corn as noted by the Spanish.[97] If Cushing's bread making is any indication, a final meal of bread made with important and prized grains in combination with cooked rabbit was prepared over this kiva

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[97] "They keep the separate houses where they prepare the food for eating and where they grind the meal, very clean. This is a separate room or closet, where they have a trough with three stones fixed in stiff clay. Three women go in there, each one having a stone, with which one of them breaks the corn, the next grinds it, and the third grinds it again. They take off their shoes, do up their hair, shake their clothes, and cover their heads before they enter the door. A man sits at the door playing on a fife while they grind, moving the stones to the music and singing together. They grind a large quantity at one time, because they make all their bread of meal soaked in warm water, like wafers. They gather a great quantity of brushwood and dry it to use for cooking all through the year" (Cushing 1920:638-639 from "Winship's" translation of Casteñeda's narrative, *The Coronado Expedition, Fourteenth Annual Report of the Bureau of Ethnology*, Washington, 1896, and a Relation of the Reverend Father Friar Marco de Niza, in Bandelier's journey of Alvar Nuñez Cabeza de Vaca).

fire, the day presumably beginning without warning of the catastrophe that would follow. The presence of brush-type shrubby fuel woods also conforms to normal collection activities.

The cheno-am example provides historical evidence of specific plant uses in cultural context. The coprolite evidence from pre-Ancestral Pueblo to Pueblo III (Reinhard 2006) tells us that these categories of plants were durably important and categorized in very specific ways.

<u>Hearth comparison 5: kiva 1206</u>

Sample FV10 (PD 243, FS5) was collected from the central hearth of a fully excavated non-typical aboveground kiva (structure 1206, block 1200; chapter seven, p. 212) distinguished by several architectural features: a subfloor ventilator tunnel and floor-level ventilation system a dual system not seen elsewhere except in the two D-shaped building kivas (1501 and 1502) and tunnels at the bench surface level that provided access to hatchway entry into corner rooms (structures 1219 and 1222). The hearth was "heavily burned" and stones present in the fill were inferred to be trivet stones (CCAC 2004, Kivas, Structure 1206). In its last episode of use, the hearth in kiva 1206 was interpreted to have been for heating, lighting, and possibly cooking. The hearth measured 67 cm in length, 57 cm in width and 30 cm in depth. In-place burning was noted to be present in stratum two and three of the deposit. Stratum three consisted of compacted light gray ash possibly due to water originating through the hatchway in the roof above. Stratum two contained burned stones (possibly trivet stones). Stratum one consisted of naturally deposited sediments.

New sample, FV10, measured 900 ml in pre-flotation volume and yielded 48.5 ml of light fraction. Due to abundant retained sediment in the smallest particle sizes, I subsampled the .71 and .25 mm portions and fully examined the 1.4 mm screen contents to compensate. The total light fraction examined was 37.4 ml. An original sample, now called "CV10" ("volume 1," PD 244, FS 1), is used for comparison purposes. This sample was 850 ml in pre-flotation volume. After flotation processing CV10 yielded a scant .7 ml of light fraction, all was examined. All data are recorded in Table E.14, Appendix E.

Original findings: CV10

No plant remains were identified. This sample appears to have consisted of naturally deposited sediment (Table 8.12, over).

New findings: FV10

The additional sample provides evidence of wood types: *Juniperus*, *Pinus*, *Amelanchier/Peraphyllum* and *Artemisia tridentata* charcoal as well as a quantity of unidentified semi-ring porous hardwood. A single *Juncus*-type (rush) achene (tentative identification) and a small number of unknowns are noted:

bud, rind fragments and tissues (a quantity of which were vitrified). Inference potential is outlined in Table 8.12. All identified remains are recorded in Table E.10 (Appendix E).

Table 8.12 Suggested inference potential: hearth comparison 5 (charred remains).

Interpretive Category	**Volume 1 (CV10)**	**New volume (FV10)**	**New taxa[a]**
Foods			
Domesticates (FD)	-	-	-
Wild resources, nonweedy (FW)	-	-	-
Wild resources, nonweedy (FN)		*Juncus*	*Juncus*
Wild Resources, other unknown (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	-	*Juniperus*	*Juniperus*
	-	*Pinus*	*Pinus*
Shrubby growth habit FLS)	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
	-	*Artemisia tridentata*	*Artemisia tridentata*
Zea mays cob remains (FLZ)	-	-	-
Tinder (FLT)	-	*Pinus*	*Pinus*
Other			
Other, ecological (OE) [seasonality]	-	*Juncus* [summer-fall]	*Juncus* [summer-fall]
Other, unknown (OU)	-	Rind fragment	Rind fragment
Other, worked (OW)	-	*Juncus* [?][b]	*Juncus* [?][b]
Genera/species count	**0**	**5**	**5**
Inferred interpretative value	**0**	**9**	**9**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.
[b][?] Assessment is based on historic Hopi use of rushes, specifically *Juncus balticus* Willd. in ceremonial contexts as symbolic of water.

Five new taxa were recovered in the additional sample, most notable is tentative identification of a rush, the achenes are easily missed due to size. The plant is a good seasonality indicator. Rush achenes are cool season perennials known to set in mid- to late summer (for *Juncus balticus* Willd.)(Hauser 2005) potentially placing the last use of this hearth in the late summer or early fall.

Juncus is a new identification for SCP and indicates the exploitation of a riparian habitat. Moerman (1998:282) documents sources that indicate the Hopi historically used rush for ceremonial items they associated with water.[98] It is most likely that the roots were used, the seeds are so minute as to be unnoticeable.

[98] The Hopi classified *Juncus balticus* Willd., *Juncus torreyi* Colville and *Scirpus lacustris* L. rushes as *mumu'ri* or one of, "all grass-like plants growing near water, particularly those with round stems and leaves" (Whiting 1939:70). These were used occasionally in ceremonials associated with water. Other plants used as symbolic of water to the Hopi include: *Populus* spp., *Salix* spp., and *Typha angustifolia* (cattail)(43). Cushing (1920:225) records the Zuni use of "certain rushes" (unspecified) for food. The roots were eaten raw or slightly toasted in ashes, dipped in salted water or used as relishes for jerked meat. Rush achenes are extremely small, requiring a microscope to see, suggesting to me that the presence of achenes signifies the use of other parts of the plant for food rather than deliberate harvesting of the achenes. *Scirpus*, *Eleocharis* and *Carex* species are known for their pharmacological activity and the use of their roots (see chapter eleven).

Evidence of unidentified rind (squash?) and an additional wild resource suggests that domesticates and wetland resources were used in or around this hearth. A quantity of semi-ring porous wood in addition to juniper and pine was burned in this hearth but an identification of type by me was not possible. Semi-ring porous woods include sagebrush, chokecherry, rose, and cliffrose and bitterbrush-types for the Sand Canyon area. None of the specimens compare favourably to the sagebrush already recorded for FV10. Uncharred material consists of unknown disseminules, insect parts and pellets. Based on this information and the lack of evidence noted in the original volume, a second sample provides nine new inferences of use and ecology that are helpful in assessing the last use of this hearth. No additional flotation samples were excavated from this deposit and the two samples evaluated are presumed to represent the total volume of the hearth. The faunal record documents bones of turkey, birds of robin size and smaller, in addition to raven remains in the kiva. It appears that turkey, squash (?) and roots were prepared here in a final episode of use.

<u>Hearth summary (Table F.3, Appendix F)</u>

The typical practice of cleaning hearths limits our ability to interpret food, fuel and other plant-associated strategies in kivas. This is not necessarily always the case, however. Increasing the number of samples evaluated for hearths in this analysis did produce additional information. New samples confirm the original interpretation of fuel use at SCP: juniper appears to be the fuel type of choice (or necessity?). *Juniperus osteosperma* and *Artemisia tridentata* remains were not recovered from hearths examined previously but are added to the record of charcoal with new samples. Utah juniper remains were recovered in new samples from hearths in kivas 517 and 1010; big sagebrush recovered in kivas 517 and 1206. Charred *Pinus edulis* wood (pine was identified at the genus-level originally) is new to all deposits at SCP. Pinyon pine is documented for kiva 517 and 1010. The underrepresentation of *Pinus edulis* charcoal in thermal features at SCP may be the result of a management strategy to ensure the production of pinyon nuts, although it is also likely that pine was not identified to the species-level. The assumption of non-specific pine, that is, “not” pinyon, could be interpreted as a decline in pinyon and the use of collapsed roof beams made of other pine species for fuel wood. With the identification of pinyon, these inferences are less supportable. The preservation of this pinyon pine would be of concern to ancient Puebloans as much as it is today because of its pinyon nut production as a significant protein source.

Pinyon pine wood and “declining resource” argument as major contributing factors in environmental degradation and the depopulation of Mesa Verde

The ethnographic record confirms the importance of pinyon pine to historic Zuni:

> In late autumn enormous quantities of sweet, diminutive acorns were gathered from the dwarf oaks which everywhere grew in the mountains of the Southwest, and still more plentiful stores of the *he´-sho-k‘u´-we*, or piñon-nuts, which are borne in prodigal plenitude on the low piñon trees of almost every mesa or mountain plateau. These nuts, together with *o´-ma-tsa’pa k‘u´-we*, or wild sunflower seed, were treated similarly in preparation for food...[which along with purslane, pigweed/goosefoot, and two grasses – one called a ricegrass]…more than on all else, depended the ancient Zuñi [sic] for his vegetable food supply (Cushing 1920:243).

Pinyon produces protein rich nuts at intervals (masting events, footnote 27, p. 116) most associated with favourable ecological conditions, conditions of which ancient people would have been well aware. To overuse pinyon pine for fuel would deplete the potential for future harvests and presumably dictate cautious use of pinyon wood. The presence of charred pinyon wood in new samples may signify the burning of dead pinyon windfall. A general trend in charcoal recovery suggests that *Juniperus* charcoal is consistently high in abundance and that *Pinus* charcoal remains are consistently lower in abundance in flotation samples at SCP. This may be the result of simply the burn patterns of both species. Clearly pine was being used in later construction at SCP and the historic tradition of using shrubs for fuel materials is documented in Cushing (1920)(see footnote 97 p. 284 for “brushwood”). Both confirm that living pinyon pine trees were not the obvious choice for fuel wood. New samples evaluated here provide abundant evidence that pinyon pine was used in most fires at SCP, the dried branches of windfall the most obvious choice.

In the original archaeobotanical analysis of hearth samples (CCAC 2015a), typical seed evidence consists of *Opuntia* and *Physalis longifolia*. New samples contained seed types that are also “new” to hearths, adding *Amaranthus*, *Chenopodium*, *Oryzopsis hymenoides*, and *Juncus*. Because subsampling was used for the smallest particle sized portions likely additional small seeds are present.

Regardless of the timing of deposition the apparent “lack of” maize in hearth samples is consistent. This may be the result of the grinding of maize in other locations with the finished product managed away from the hearth. The possibility that blackened stones in or associated with hearths were used to make bread (*piki* bread comes to mind) has not been adequately explored. Coprolites indicate that ground maize and seeds were a staple part of Ancestral Pueblo diet. Alternative explanations include deposits that accumulated prior to maize harvest, the result of a poor harvest, preference or little cooking activity. The common use of grinding technology such as metates and manos and the larger metate bins testify to stored maize and flour. The seasonal timing of deposition is an importance indicator of maize processing. In 2004, Adams et al. (2006) evaluated maize growing conditions by planting a variety of maize types in mid May at Farmington, New Mexico, approximately 100 km south of Sand Canyon. Harvesting occurred in mid-October of that year. If the Farmington study is indicative of maize growing conditions in southwestern Colorado, mature maize would not be available at SCP until the late fall. The lack of this crucial domesticate in latest occupation deposits may be caused by a combination of ground maize, depleted stores from previous years and pre-harvest context at the time the village was abandoned. The attack may have been planned in association with post-harvest storage and the purpose of a raid intended to acquire harvested maize. If the last days of occupation occurred in the spring or summer this might provide a plausible alternative explanation for lack of maize in primary refuse contexts and bears further scrutiny.

Nineteen hearth flotation samples were originally assessed for SCP. The analysis of additional samples here provides a new genus (*Juncus*) and enhanced information about plant use at or near hearths. Because of clean-outs, hearths are likely the least productive of food-activity features. The next section covers two types of secondary refuse, formal middens and trash. The contents of these accumulations can shed light on general subsistence strategies over periods of time and what constitutes unwanted materials. The expectations of sampling effects are considerably greater due to the volume of material in these deposits.

Results—secondary refuse

Middens

I assessed four trash accumulations interpreted as “middens” with the expectation that a single one-litre flotation sample will capture only a fraction of recoverable species that might be present in deposits of this type. More samples provide an opportunity to assess how well a single one-litre sample accounts for microscopic plant evidence in terms of interpretative content in comparison with other samples from the same contexts. All midden sample data are summarized in Table F.4, Appendix F and individually by comparison in Appendix E. Three of the midden samples are also subject of species area curve evaluation and additional information is available in chapter nine.

<u>Midden comparison 1: midden 209</u>

Midden 209 (structure 209) is described in chapter seven (p. 189) and distinguished by the quantity of tools. The midden likely served as the trash dump for the remodeled *tower/kiva* (structure 208), both contained a variety of awls, axes, manos and metates. A stone mortar (kiva 208) and a *tchamahia* (room 203), historically are linked with ceremony. The block was occupied at the time of the final attack. The samples examined here were located immediately above sterile (natural bedrock) and below two overlaying secondary refuse layers, collapsed walls and naturally deposited sediments. The dimensions of the midden are unclear (CCAC 2004 Cultural Deposits, Nonstructure 209). No tree-ring cutting dates are available for the tower or the remodeled kiva but the reconstruction event occurred sometime after A.D. 1244. Construction of the site-enclosing wall in this section is estimated in the A.D. 1250s, much like the wall and tower in block 100 (Kuckelman et al. 2007). If this is accepted, the date of remodeling of the tower into a kiva may have occurred at around the same time. Samples from the lowermost layers of refuse could capture the earliest kiva trash, trash that should reflect presumably typical and "normal" activities. Based on the stratigraphic positioning of the samples and early estimated dates of kiva construction, the samples assessed are interpreted by me to represent trash from the earliest-early occupation of the kiva and the village, possibly in the late A.D. 1240s to early 1260s. The presence of a second undated midden (midden 210) may have been associated with kiva activities also.

New flotation sample, FV11 (PD 184, FS 126), was collected from one surface above sterile. FV11 originally measured 800 ml in pre-flotation volume and produced 55 ml of light fraction and I examined 35.9 ml. I evaluated the 1.4 mm portion without subsampling because it required little effort and subsampled the .71 and .25 mm screens. The findings are compared with two previously analyzed samples (now labeled CV11a and CV11b) from the same midden, segment, and stratum (segment 1, stratum 2) collectively referred to as "volume 1," (PD 184, FS 73 and PD 184, FS 76). Both these samples were of unknown pre-flotation volume but total light fraction for both samples combined measured 50 ml. All 50 ml was evaluated in the original analysis.

Original findings: CV11a, CV11b ("volume 1")

The two comparison samples together ("volume 1") contained *Juniperus* and *Pinus* charcoal and evidence of tinder in the form of pine bark scales. A variety of shrubby taxa are documented consisting of *Amelanchier/Peraphyllum, Artemisia tridentata*, *Cercocarpus, Quercus, Populus/Salix*-types and an unidentified diffuse porous hardwood. A small quantity of *Zea mays* is recorded (cob, cupule and kernel remains) suggestive of ground maize.

New findings: FV11

The new sample yielded similar remains with an additional shrubby fuel wood in the form of *Chrysothamnus* charcoal. The quantity of *Juniperus*, *Pinus* (identified as *P. edulis*) and *Zea mays* is more abundant in this sample and based on kernel fragments also suggests the discard of ground corn. I observed an abundance of uncharred botanical and nonbotanical remains that indicate a disturbed, mixed or well-preserved deposit. A land snail, *Vertigo*-type is also new, only one gastropod was previously identified (Muir 2007)(Appendix C). Table 8.16 outlines possible inference values.

The original analyses of "volume 1," a combination of two samples of minimal volumes (20 ml and 30 ml), produced eight genera/species. Ten inferences of use could be proposed from the combined taxa. Maize is captured in two of the original samples only. The new sample yielded eight charred taxa although conservatively only one is new to the deposit (*Chrysothamnus*). Uncharred remains include abundant *Juniperus osteosperma* twigs and scale leaves and *Pinus edulis* needles and several Poaceae florets and a *Portulaca retusa* seed. Insect parts and pellets were observed. Whether these are ancient or modern is unknown (Table E.11, Appendix E).

Midden 209 accumulated outside the walls of the remodeled tower/kiva (structure 212/208) and was buried under collapsed walls and sediment, which may explain the abundance of uncharred and nonbotanical remains noted for the new sample. Uncharred materials are not unusual for SCP and may be due to an accumulation protected under debris or within the confines of buildings. A wide variety of faunal remains were identified from the bones and fragments of bones recovered here consisting of a range of large and small mammals (readers are referred to the database [CCAC 2004, Cultural Deposits, Middens, Nonstructure 209, Animal Bone Analysis Summary]). Two unusual bird species however, are represented: a bone awl made from an owl (*Strigiformes*) and evidence of a hawk (*Buteo* sp.). These predatory birds were found in block 100, 1000, the great kiva and the D-shaped building. It is unlikely that they were used as food but suggests spiritual themes, the capture of birds of prey and use in ceremony is documented in historic records (Muir 1999, 2007).

If the midden contents represent trash from the kiva hearth and the date I propose ("earliest" occupation) is any indication, there was a wide variety of fuels being used, most notably shrubs in the kiva fires, similar to the historic period. Preservation or insect and animal disturbance may have played a role in the apparent "absence" of food remains. No additional flotation samples were excavated from this deposit and these samples may represent the obvious content of the midden (Table 8.13).

Table 8.13 Suggested inference potential: midden comparison 1 (charred remains unless otherwise specified).

Interpretive Category	Volume 1 (CV11a)	(CV11b)	New volume (FV11)	New taxa[a]
Foods				
Domesticates (FD)	*Zea mays*	-	*Zea mays*	-
Wild resources, weedy (FW)	-	-	-	-
Wild resources, nonweedy (FN)	-	-	-	-
Wild resources, other (FO)	-	-	-	-
Fuels				
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Amel./Pera.*[b]	-	*Amel./Pera.*[b]	-
	A. tridentata[c]	*A. tridentata*[c]	*A. tridentata*[c]	-
	Quercus	-	-	-
	-	*Cercocarpus*	-	-
	-	*Populus/Salix*	-	-
	-		*Chrysothamnus*	*Chrysothamnus*

continued…

Table 8.13 Suggested inference potential: midden comparison 1 (charred remains unless otherwise specified), continued.

Interpretive Category	Volume 1 (CV11a)	(CV11b)	New volume (FV11)	New taxa[a]
Fuels, continued…				
Zea mays cob remains (FLZ)	-	*Zea mays*	*Zea mays*	-
Tinder types (FLT)	*Pinus*	*Pinus*	*Pinus*	-
	-	-	*Pinus edulis*	*Pinus edulis*
	-	-	*A.tridentata*	-
Other				
Other, ecological (OE) [seasonality]	-	-	-	-
Other, unknown (OU)	-	-	Fruit top unknown	Fruit top unknown
	-	-	Gastropod (*Vertigo*-type, uncharred)	Gastropod (*Vertigo*-type, uncharred)
				-
Other, worked (OW)	-		-	
Genera/species count (combined CV11)		**8**	**8**	**3**
Inferred interpretative value (combined CV11)		**10**	**12**	**6**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.
[b] *Amelanchier/Peraphyllum*-type.
[c] *Artemisia tridentata*-type.

Midden comparison 2: midden 515

Two samples are compared for this midden found near the only excavated subterranean kiva at SCP (kiva 501, block 500). The midden was exposed in a test pit and may have served as the trash site for refuse from kiva 501 and the great kiva (800) located nearby. If this was indeed the case, the midden then likely contained remains from two architecturally distinctive buildings (additional information is outlined in chapter seven, kiva 501 pp. 195-196; the great kiva, pp. 199-201). Midden 515 was exposed in a 50 cm wide trench below a natural surface and contained a collection of artifacts and large pieces of wall fall in the first strata. The depth of the accumulation is unclear but overlays another cultural level thought to be construction fill above bedrock. Investigators inferred that the midden was in use throughout the occupation and discontinued at the abandonment of the block and the depopulation of the village (CCAC 2004: middens, nonstructure 515). Samples were collected from one stratum above bedrock from the center of the midden. Stratigraphic placement and early dates associated with both block 500 and the great kiva nearby suggest that deposition occurred in the A.D. 1250s or 1260s reflecting a pre-drought timing and, presumably, “normal” activities and discard. The samples compared here were recovered from the center of the midden. Based on placement above what was thought to be construction fill, I tentatively interpret the samples as deposited during a period of settling in, occurring in the A.D. 1250s to A.D. 1260s when the construction of the great kiva began. Certainly these samples represent activity that plausibly occurred prior to the A.D. 1270s when shifts in behaviour are evident elsewhere. For that reason their content is valuable for comparative purposes with later occupation deposition.

The new sample, FV12 (PD 701, FS 40) measured 1000 ml pre-processing and produced 47.6 ml of light fraction after flotation. Due to the abundance of retained sediment in the smallest light fraction particle sizes, I examined the contents of the 1.4 mm screen but subsampled the .71 and .25 mm portions examining 28.9 ml in all. Comparison sample CV12 ("volume 1," PD 701 FS 41) originally measured 1000 ml and produced 68 ml of light fraction of which 54 ml was examined. This sample was also used to explore the species-are curve (see "SC7," chapter nine). All data for both samples are recorded in Table E.12 (Appendix E).

Original findings: CV12

In addition to *Juniperus*, *Pinus*, *Prunus/Rosa*-type charcoal, *Zea mays* cobs were identified in this sample. A single *Pinus* bark scale was recorded.

New findings: FV12

More tinder and shrub-type fuel materials are represented in the new sample and includes *Juniperus* and *Pinus edulis* charcoal. Shrubs include *Chrysothamnus, Prunus/Rosa,* and *Purshia* (cliffrose) identified as *Purshia mexicana*-type based on a good match with charred modern comparative material).[99] *Juniperus osteosperma* (scale leaf) and *Purshia tridentata* (bitterbrush)(leaf) were also noted. *Zea mays* cupules suggested the use of cobs as fuel. As is the case for Midden Comparison 1, there is a considerable amount of uncharred material, which I presume to be modern but may be the result of excellent preservation notable for the site.

The original volume yielded four genera/species and five potential inferences of use based on the categories defined. The additional volume provided nine genera/species, four are new to this deposit. Two new taxa include both bitterbrush and cliffrose counted as a single taxon as both are similar. Contemporary groups do not specifically distinguish between them (Dunmire and Tierney 1997:168) and I am presuming the same although this is unlikely to be the case. The Hopi are documented as using bitterbrush leaves as an ingested medicine for various unspecified ailments. Shredded cliffrose bark is identified as baby diaper matting, a cultural preference over other species

[99] I distinguished between the two species of bitterbrush/cliffrose based on wood and leaf morphology (three-lobed leaves are always bitterbrush [Dunmire and Tierney 1997:168]). My assessment of wood remains as cliffrose is made based on the distinction that the ancient specimens more closely resemble my charred cliffrose comparative wood samples and do not compare well with the bitterbrush specimens. Ethnographic uses of these types are interesting and might provide a line of evidence for inferring the presence of specific types in particular contexts. Cliffrose was used differently than bitterbrush.

such as shredded juniper bark because of absorbency (170)(The Navajo term for baby cradle is the same as that of the cliffrose plant attesting to its use in this regard [Dunmire and Tierney 1997:170]). As of 1997, Dunmire and Tierney caution that only one reference to cliffrose/bitterbrush charcoal is noted for the archaeological record from a single site at Chaco Canyon and speculate that this likely due to the difficulty in distinguishing rose family species archaeologically. This is certainly true. An alternative explanation could include *Purshia* for its bark as serving mundane purpose associated with the family.[100] Table 8.14 provides an outline of inference potential for the two samples.

Table 8.14 Suggested inference potential: midden comparison 2 (charred remains).

Interpretive Category	**Volume 1 (CV12)**	**New volume (FV12)**	**New taxa[a]**
Foods			
Domesticates (FD)	-	-	-
Wild resources, weedy (FW)	-	-	-
Wild resources, nonweedy (FN)	-	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	-
		Pinus edulis	*Pinus edulis*
Shrubby growth habit (FLS)	*Prunus/Rosa*	*Prunus/Rosa*	-
	-	*Chrysothamnus*	*Chrysothamnus*
	-	*Purshia mexicana*	*Purshia mexicana*
Zea mays cob remains (FLZ)	*Zea mays*	*Zea mays*	-
Tinder types (FLT)	*Pinus*	*Pinus*	-
		Juniperus osteosperma	*Juniperus osteosperma*
Other	-	-	-
Other, ecological (OE) [seasonality]	-	-	-
Other, unknown (OU)	-	*Purshia tridentata*	*Purshia tridentata*
Other, worked (OW)	-	-	-
Genera/species count	**4**	**9**	**4**
Inferred interpretative value	**5**	**10**	**5**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.

No additional flotation samples were excavated from midden 515. Nothing about the faunal remains suggests anything special occurring near this midden, the remains consist mainly of turkey, bones from large birds, jackrabbit/hare, cottontail and smaller mammals.

[100] See firepit comparison 2 for discussion of mundane, medicinal and ceremonial uses of *Purshia*. Evidence of *Purshia* charcoal has been identified in samples from arbitrary unit 1 burned spots, courtyard 1000, in block 1200, "storage" room 204, roof fall in block 300, 1000, 1200 and in cultural deposits in the D-shaped building. An abundance of *Purshia* seeds were found in kiva 1204 and the D-shaped tower room 1008 in mixed refuse deposits from vegetal samples. Approximately 2000 *Purshia* seeds were located in the fill above the kiva corner rooms (1219 and 1220) of kiva 1206.

Midden comparison 3: great kiva midden 803

The samples evaluated for this comparison were collected from trash thought to have originated from the great kiva (structure 800) located in a space where a peripheral room would be expected exposed in an excavation unit. Excavators noted a diversity of tools, beads, minerals, plant and animal remains in the midden (chapter seven, p. 205). As previously noted, the use of the great kiva seemed to shift becoming a more disordered space towards the end of the occupation. Use of the midden seems to have been discontinued when the use of the great kiva ceased sometime prior to the end of village occupation that is, sometime after A.D. 1277 (CCAC 2004: Kivas, Structure 800). The samples were collected from sediments in the second stratum, unspecified depth, below wall fall and above indeterminate fill. Dating of this accumulation is problematic for this reason. I'm assessing these samples as occurring during the transition of the great kiva circa mid A.D. 1270s. A comparison sample (CV13b) was also assessed for the effectiveness of the SAC subsampling approach, the results presented in chapter nine (SC9, pp. 361-364), those results are not included here.

New flotation sample FV13 (PD 1008 FS 112) was originally 1000 ml and produced 64.5 ml of light fraction. I subsampled only the .71 and .25 mm portions and fully examined the 1.4 ml portion due to low sediment content in that screen for a total examined volume of 45.5 ml. The content is compared to two previously examined 1000 ml volumes from the same context, (PD 1008, FS 107 and PD 1008, FS 113), now labeled collectively as "volume 1" or CV13a and CV13b. Both samples measured under 50 ml of light fraction and were subsampled, presumably in all screen portions. All sample data are detailed in Table E.13, Appendix E.

Original findings: CV13a, CV13b ("volume 1")

The two previously examined samples together provide evidence of *Cucurbita* rind, *Zea mays* cupules and kernel and *Physalis longifolia* as food resources. *Juniperus* and *Pinus* charcoal is recovered in this sample in small quantities. Shrubby taxa include *Amelanchier/Peraphyllum* and *Cercocarpus*. An unidentified fruit rind was recorded. Suggested inference values are outlined in Table 8.15.

Table 8.15 Suggested inference potential: midden comparison 3 (charred remains unless otherwise specified).

Interpretive Category	Volume 1 (CV13a)	(CV13b)	New Volume (FV13)	New taxa[a]
Foods				
Domesticates (FD)	*Cucurbita*	-	-	-
	-	*Zea mays*	-	-
			Phaseolus vulgaris	*Phaseolus vulgaris*
Wild resources, weedy (FW)	*Physalis longifolia*	-	-	-
Wild resources, nonweedy (FN)	-	-	Cheno-am	Cheno-Am
Wild resources, other (FO)	-	-	-	-

continued…

Table 8.15 Suggested inference potential: midden comparison 3 (charred remains unless otherwise specified), continued.

Interpretive Category	Volume 1 (CV13a)	(CV13b)	New Volume (FV13)	New taxa[a]
Fuels				
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	-	*Amelanchier/ Peraphyllum*	*Amelanchier/ Peraphyllum*	-
	-			-
	-	*Cercocarpus*	*Cercocarpus*	-
	-	-	*A. tridentata*	*Artemisia tridentata*
	-	-	*Purshia*	*Purshia*
Zea mays cob remains (FLZ)	*Zea mays*	*Zea mays*	*Zea mays*	-
Tinder types (FLT)	*Pinus*	*Pinus*	*Pinus*	-
	-	-	*Ceratoides lanata*	*Ceratoides lanata*
Other				
Other, ecological (OE)	*Physalis longifolia*	-	-	-
[seasonality]	[fall]	-	Termite fecal pellet (uncharred)	Termite fecal pellet (uncharred)
	-	-		
	-		Cheno-am [summer]	Cheno-Am [summer]
Other, unknown (OU)	Fruit rind[?]b	Fruit rind[?]b	-	-
	-	-	-	-
Other, worked (OW)	-	-	-	-
Genera/species count (CV13a and b combined)		**7**	**11**	**7**
Inferred interpretative value		**11**	**13**	**8**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

[b] The analyst noted that the identification is “questionable.

New findings: FV13

The new flotation sample provided additional information about discard in this midden. *Phaseolus vulgaris* (common bean) and cheno-am seeds are added to food-types. FV13 provides the typical charcoal remains of *Juniperus* and *Pinus edulis*. A *Zea mays* cob fragment may represent the use of cobs for fuel material. A wider range of shrubby taxa includes *Artemisia tridentata*, *Ceratoides lanata* (winterfat) and *Purshia*. Termite fecal pellets could be the result of burning termite-infested wood (as per Adams et al. 2007; Adams 1984).

Data from two original flotation samples (“volume 1”) when combined provide a count of seven new genera/species and there are some differences in recovery between the samples. A range of wood types and some evidence of maize cobs suggest fuel materials. Two domesticates, squash and maize and groundcherry hint food types in a later temporal context. With the analysis of an additional sample, another domesticate, common bean, is added to the list of domesticated foods used in this kiva. The recovery of this food type in an exposed midden is indicative of the excellent preservation conditions. If the temporal context is correct (“late-latest”), then this domesticate was discarded as a food source in what appears to be a once important public location. *Phaseolus vulgaris* remains are most frequently found in abandonment contexts also proof of good preservation conditions. Whether from stored beans on roofs of collapsed buildings or, as is the case in kiva 102, on the floor, evidence of beans in the absence of maize is not supportive of a definitive interpretation of resource stress. An alternative explanation is bean harvest prior to maize harvest. The identification of cheno-am seeds has several unaccounted for values: as a seasonality indicator (summer/early fall), which in the context of middens is of debatable value, or as a stored resource. Taxa such as big sagebrush, cliffrose/bitterbrush-type and winterfat suggest that a variety of shrubs were discarded in this setting. Seven new genera/species are added to the list of plants with the addition of another flotation sample. No record of winterfat is documented for SCP as of this writing. Termite pellets suggests the re-use of degraded building materials. Six additional flotation samples were collected from this deposit. All samples are unprocessed and archived for future analysis should that be considered. Additional analysis may well shed more insight into late occupation great kiva activities.

Midden comparison 4: the *smoldering trash midden* 1214

Midden 4 (nonstructure 1214, block 1200) is described as a "smoldering trash dump," (CCAC Provenience Designation Report, accessed 2008) and may be the most significant accumulation of refuse currently excavated. The samples I have compared here came from the lowermost stratum of this deposit (CCAC 2004: Middens, Nonstructure 1214). The midden area has a convoluted history. Located in a structure immediately outside, and attached to a circular tower (structure 1203), the space was originally a mealing room (structure 1212), the presence of a three-trough mealing bin clearly indicating that grinding and processing of plants occurred here. The north side room was interpreted as used for storage. After an unknown period of time, the rooms were used as a midden. On excavation the northernmost room (1204) was noted to have maize cob impressions in the adobe coping. Certainly the transition of the mealing room into a garbage area suggests that shifts in priorities events that may be associated with shifts in occupancy we see after the completion of the D-shaped building final kiva (1502) I estimate as ca. A.D. 1274-75 or later. The content of the midden reflecting late occupation activities, situated in a time of transition prior to the final events that caused collapse of the occupation. The data collected from both FV14 and the comparison volume (CV14) are presented in Table E.14 (Appendix E).(Excavation details are provided in chapter seven, pp. 214-215). A species-area curve sample (SC9, chapter nine, pp. 364-373) is also evaluated.

Flotation volume (FV14), its comparison sample (CV14) and a species-area curve sample (SC9) were collected from this midden. The FV14 and CV14 samples were recovered from a stratum below the SC9 sample, which appears to be located two surfaces below modern ground surface and three surfaces above sterile, all occurred after A.D. 1265 (the last tree-ring date for kiva suite construction) but reflect a transition in the use of the kiva suite with the remodeling of rooms and the shifts in activities that places the midden content in later occupational time. The samples likely reflect transitions, after what could have been previously "normal" activity for Sand Canyon residents occurring as late as the mid to late A.D. 1270s based on the inferred transitions for the D-shaped building.

New flotation sample FV14 (PD 359 FS 233) was thought to be a single 1000 ml sample although the original volume may have been as great as three litres before flotation. Total light fraction after processing was 574 ml, the largest quantity of all light fraction samples for SCP with the exception of the comparison volume for this same deposit, both samples produced a quantity and diversity of remains. I subsampled the light fraction in all screens due to the significant quantities of sediments and matrix. Unlike the other FV samples, I did not examine the 1.4 mm portion completely because of the enormous volume in this screen but attempted to do so, stopping at 29 subsamples of .90 ml each and taking approximately two hours of examination time. The two smallest particle sizes were subsampled as standardized in the SAC approach. In all, I examined 146.4 ml of light fraction. The sample yielded a wide variety of new genera, species and insights. The material is so comprehensive it stands as a caution for presuming adequacy of limiting midden samples! FV14 is compared with a 1000 ml volume previously analyzed from the same deposit and stratum now called CV14 or "volume 1," (PD 359, FS 203). CV14 yielded 255 ml of light fraction and the previous analyst examined 65 ml. Additional samples were evaluated from the midden but from different strata, four samples were collected from later layers (a discussion is presented in chapter nine).

Original findings: CV14

The original sample contains fuel wood identified as *Juniperus*, *Pinus* and includes evidence of *Artemisia tridentata*, *Fendlera* (fendlerbush), and *Purshia* charcoal. An unknown diffuse porous wood type is recorded. *Juniperus osteosperma* and *Pinus* parts are interpreted as tinder materials. A quantity and quality of *Zea mays* remains are recorded, 50 cob fragments, a number of cob parts and a few kernel fragments. Wild plant food resources are limited to cheno-am seeds.

New findings: FV14

FV14 also contained an abundance of uncharred remains that included ancient domesticates testifying to excellent preservation. New genera/species and parts are important for the interpretation of the site and a discussion of the more unique remains follows, broken down by category. All data including nonbotanical and uncharred remains are listed in Table E.14, Appendix E. Fuel wood remains are varied. *Juniperus* and *Pinus edulis* charcoal and shrubby woods are well-represented. These include

Amelanchier/Peraphyllum (some identified to *Amelanchier utahensis* [Utah serviceberry], a new identification for SCP), *Artemisia tridentata*, *Atriplex*, *Ceratoides lanata*, *Cercocarpus*, *Fendlera*, *Purshia* (cliffrose/bitterbrush-types) and the more specific identification of *Purshia tridentata* (bitterbrush). Wood, twigs, buds, and cones from these species could be present as tinder or the result of other unknown activities.

Charred maize in various forms such as glumes, immature kernels, kernel fragments and kernel embryos are not associated with the original mealing bins based on stratigraphic placement. Other domesticates include *Cucurbita moschata* (butternut squash) and *Cucurbita pepo* (pumpkin). Only three locations contained *C. moschata* evidence. These were also found in room 1205, the lower storey of an adjacent room noted to contain a *tchamahia* and one that contained a variety of basketry items and reed grass “cigarettes” (CCAC 2004: Rooms, Structure 1205). D-shaped building peripheral room 1513 also contained *Cucurbita moschata* seeds. FV14 also contained squash (*Cucurbita* sp.) rind fragments and rind fragments that matched gourd variety (*Lagenaria*)(another species also found in room 1513)(see Appendix C for identification criteria). Two *Phaseolus vulgaris* specimens also preserved in this sample. Wild plant food evidence consists of the reproductive parts (achenes, caryopses, embryos, florets, and seeds) of *Amaranthus*, *Artemisia tridentata*, *Atriplex*, *Bromus*-type (similar to brome grass), cheno-am, *Chenopodium*, *Opuntia* (prickly pear), *Physalis longifolia*, *Polygonum* (bindweed), *Portulaca retusa*, *Oryzopsis hymenoides* and a number of achenes and seeds that I wasn’t able to identify. Yucca, likely *Yucca baccata* (datil yucca) leaves and twisted Fibers, and a drilled *Juniperus osteosperma* seed (photograph D.9 and D.11, Appendix D) suggest that jewelry and clothing materials were discarded here. I observed a number of distinctive grass stem types I label Poaceae A, B and C-types. Photographs can be found in Appendix D: A-type (photograph D.36 and D.37), B-type (photographs D.38-D.40), and C-type (photographs D.41-D.43). An abundance of difference buds, seeds, and tissues are noted for this sample. Nonbotanical taxa include termite fecal pellets and the well-preserved remains of a ground beetle species (tentatively identified here by me as Carabidae-*Harpalus* type) based on similarities with Alden et al. (1999) and Elias 1994’s descriptions (see also Appendix C).

Harpalus beetles live in underground debris and are active in July in the Southwest.[101]

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[101] As reported to M. R. F. Colton (in Whiting 1939:6-7) all forms of life, whether human, animal, bird, insect, tree or plant have souls which upon death return to their own worlds according to Hopi worldview. There are exceptions, at least two animals do not have souls of their own but “dark souls” of people who have lived previously and are “being punished” in this life for their misdeeds. Of these, one is the Pinacate beetle (*Eleodes* sp.), the other, a small night moth. When these animals perish their souls also cease to exist. *Eleodes obscurus* (darkling beetle or clown beetle/Family Tenebrionidae) has elytra similar to the ones I tentatively identify as *Harpalus*. Darkling beetles are found in Mexico and the southwestern U.S. (Alden et al. 1999). Beaglehole

The original flotation sample yielded eight genera/species for the interpretation of this midden potentially contributing ten inferences of use and ecology. The interpretation would have suggested that two food resources were discarded here (maize and cheno-am), juniper, pine and maize cobs served as fuel sources for nearby fires. Shrubby taxa (big sagebrush, fendlerbush and cliffrose/bitterbrush) may have served as tinder material or used for other purposes. Based on this sample, little food remains would be accounted for in this late occupation trash and fuel needs were met primarily by juniper and pine. With the addition of another sample an additional new thirty genera/species are added to the plant record of midden 1214 contributing approximately 43 inference values. The interpretative differences are significant.

It is expected that midden samples will provide a glimpse of a general economy of plant use. Midden 1214 is a particularly interesting example, the two samples compared here being from a provenience within the deposit described as "smoldering trash" where the organic material preserved in this layer was found in association with a "heavy concentration" of artifacts, ash, burned sand, adobe, and building block sized sandstone (CCAC 2004, Nonstructure 1214, Provenience Information). The analysis of additional volume (FV14) provides a startling example of why additional sampling and a revisiting of strategy are important. Although possibly as much as three litres in total excavated volume, the additional sample adds considerable information about later occupation plant discard (Table 8.16, over) .

(1937:15) records one of the Hopi legends of the Coyote clan in a narrative on land distribution and proper tenure on the Mesas as told by "an old man of the Cedarwood-Fire-Coyote clan, translated by his son," which I abridge here: "It grew crowded there. It got so bad that the clans came to Coyote clan and asked that clan to make rules for the land to prevent further trouble. This fox could talk, he was like a man only he had furry skin and was small... The fox agreed. He made prayer feathers using the little neck feathers of the eagle, the feathers of the woodpecker and the feathers of the little bird Dïwï/zi. To each prayer feather he tied a *hoho'yawa*, a small blind black bettle [sic] and a Divï'mokwa, a spider with red striped legs and a poisonous fiery sting. Then he took these prayer feathers into the fields and dug a deep hole, an arm's length deep. He built a fire in the hole, put the prayer feathers on top and filled in the hole with sand. He built another fire on top of this place and put on this fire a stone marked with clan signs on two opposite sides. He went around the land dividing it up thus for all the clans and all the villages...The fox gave the same sized lands to each clan...[t]here was no trouble until Christian Hopi tried to beak everything up by taking no notice of boundaries..." The beetle *hoho'yawa* is also recorded as used in the preparation of snake emetic medicine and medicine for war ceremonies (Beaglehole 1937:15).

Table 8.16 Suggested inference potential: midden comparison 4 (charred remains with the exception of mineral).

Interpretive Category	Volume 1(CV14)	New volume (FV14)	New taxa[a]
Foods			
Domesticates (FD)	*Zea mays*	*Zea mays*	-
	-	*Cucurbita moschata*	*Cucurbita moschata*
	-	*Cucurbita pepo*	*Cucurbita pepo*
	-	*Phaseolus vulgaris*	*Phaseolus vulgaris*
Wild resources, weedy (FW)	Cheno-am	Cheno-am	-
	-	*Amaranthus*	*Amaranthus*
	-	*Chenopodium*	*Chenopodium*
	-	*Bromus*	*Bromus*
	-	*Physalis longifolia*	*Physalis longifolia*
	-	*Portulaca retusa*	*Portulaca retusa*
	-	*Stipa hymenoides*	*Stipa hymenoides*
Wild resources, nonweedy (FN)	-	*Opuntia*	*Opuntia*
	-	*Polygonum*	*Polygonum*
Wild resources, other (FO)	-	*Artemisia tridentata*	*Artemisia tridentata*
	-	*Atriplex*	*Atriplex*
	-	*Ephedra*	*Ephedra*
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	-
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Artemisia tridentata*	*Artemisia tridentata*	-
	Fendlera	*Fendlera*	-
	Purshia	*Purshia/P. tridentata*	*Purshia tridentata*
		Cercocarpus	*Cercocarpus*
Zea mays cob remains (FLZ)	*Zea mays*	*Zea mays*	-
Tinder types (FLT)	*Juniperus osteosperma*	*Juniperus osteosperma*	-
	Pinus	*Pinus*	-
	-	*Pinus edulis*	*Pinus edulis*
	-	*Amelanchier utahensis*	*Amelanchier utahensis*
	-	*Artemisia tridentata,*	*Artemisia tridentata*
	-	*Ceratoides lanata*	*Ceratoides lanata*
Other			
Other, ecological & unknown (OE/OU)[seasonality]	cheno-am [summer/fall]	*Amelanchier utahensis*	*Amelanchier utahensis*
	-	*Artemisia/A.tridentata* [spring]	*Artemisia/A.tridentata* [spring]
	-	*Atriplex*	*Atriplex*
	-	Carabidae *Harpalus[?]*-type	Carabidae *Harpalus[?]*[b]-type
	-	*Ephedra* [spring/summer]	*Ephedra* [spring/summer]
	-	Poaceae (unk, A,B,C)	Poaceae (unk, A.B.C.)
	-	*Purshia tridentata*	*Purshia tridentata*
	-	*Stipa hymenoides* [spring]	*Stipa hymenoides* [spring]
	-	*Yucca baccata*	*Yucca baccata*
	-		
Other, worked (OW)	-	*Cucurbita*	*Cucurbita*
	-	*Lagenaria*	*Lagenaria*
	-	*Juniperus osteosperma* (bead)	*Juniperus osteosperma* (bead)
	-	*Yucca/Y. baccata*	*Yucca/Y. baccata*
	-	Fe Illite/glauconite mineral	Fe Illite/glauconite mineral
Genera/species count	**8**	**30**	**@30**
Inferred interpretative value	**10**	**@43**	**@43**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

It is difficult to make a case for food stress in this accumulation that clearly occurred after occupation of the kiva suite changed, conditions that might be expected as a result of drought based on inferred timing. The content and abundance of sample FV14 supports an interpretation of disregard for food waste, one that is supported by plant evidence of a similar kind in "storage" room 1205 (see p. 215). The residents of block 1200, that I argue were residing there late in the occupation based on similar plant evidence in the D-shaped building, we not short of food, medicine and fuel supplies. The new sample yields evidence of various domesticates in this stratigraphic layer. A breakdown by interpretative category follows that focuses on the most unusual remains recovered in the new sample.

<u>Domesticates</u>. The archaeobotanical record for Sand Canyon Pueblo identified maize fragments consists of a single *Zea mays* embryo recovered in a flotation sample from the sealed southeast firepit in room 1008, the low height D-shaped tower room of block 1000 (see firepit comparison 3, pp. 261-266). Fifty maize glumes were recovered in a vegetal sample collected from below one of the plaza surfaces in the open courtyard/plaza area outside the west kiva of the D-shaped building (nonstructure 1500), timing of deposition prior to A.D. 1266, the estimated date for construction here. Maize processing is likely to leave a signature of glumes, crushed kernels and kernel embryos. This evidence is clearly present in the new sample for midden 1214 deposited in a distinct layer above an accumulation of refuse on the floor of the mealing and storage room. As materials of this size are likely to fall into the smallest screens, subsampling likely has an impact on recovery and assessments of corn meal as a subsistence staple. The result, "ground maize" as an important category of analysis that becomes increasingly invisible. Accounting for fragments, even quantities of "unknown fragments/tissues/other" may help solve the apparent missing maize problem. Processing of other domesticates can be seen in evidence of crushed and broken squash seeds and the presence of rinds. These remains recovered from sample FV14 are suggestive of the traditional practice crushing squash seeds for the oiling of metate stones for the making of *piki* bread with finely ground maize (Robbins et al. 1916). Other new taxa such as butternut squash, pumpkin, and gourd/squash seeds were recovered previously but only in vegetative samples for midden 1214 and from vegetative and a flotation sample collected from rooms 1205 and 1513 noted for its red and white plaster, green pigment and dog skeleton. *Cucurbita* seeds are recorded for kiva 517 and room 803. Even less commonly identified in the Sand Canyon Locality, only 10 uncharred *Cucurbita* seeds and an uncharred *Cucurbita pepo* seed were recovered in samples from two subterranean kivas at Castle Rock Pueblo and four charred *Cucurbita*-type seeds were identified from a midden sample at Yellow Jacket Pueblo. Common beans were present in previously examined vegetative samples, most in abandonment contexts, and until the new sample, none encountered in flotation samples. The

presence of fragile common bean and other uncharred domesticates from this sample confirm good preservation conditions and that the content reflects a diversity of subsistence remains in a time more associated with actual or looming drought and evidence of a shift in priorities.

Fuel materials. Previously pinyon pine at Sand Canyon Pueblo was identified based on cone scales (one of which is uncharred). As charcoal discarded in late occupation deposits, pinyon is an interesting fuel choice. Much of the pine I identify is pinyon, its characteristic resin canals observable in even the smallest of fragments. As previously noted, pine is a building material for construction beams in the ethnographic record. The need for straight, large and lengthy trunks for the construction of roof beams and ladders make pinyon pine trunks and branches the least desirable choices, Colorado pinyon is most noted for its low bushy growth and short, crooked trunk (Anderson 2002). The straight, long trunks and branches of Ponderosa pine are clearly more effective. Pinyon pine's slow growth pattern, it can reach 500 – 1,000 years of age, means that overharvesting would have serious consequences. How much the SCP people were willing to harvest and burn pinyon trees at the risk of losing a pinyon nut supply is an important question for this species. It is also a question for assessments of overharvesting particularly in light of the fuel crisis and stripping of trees that occurred at Chaco Canyon, not so far removed in time as to be obliterated in story for the people of Mesa Verde. Colorado pinyon is known to produce its initial crop of nuts when trees reach 75-100 years of age (Anderson 2002). Much like the slow growing juniper, these trees take time to establish and significant time to be productive as food and fuel sources. The shrubs found in thermal features, consistent with traditional burning of shrubby taxa for fuel in the historic period, suggest that pinyon may have been a tinder material for the most part consisting of dried and dead branches and needles. Certainly a plausible explanation for the burning of non-pinyon pine could be explained by the burning of roof supports not made of pinyon.

The dominance of juniper wood in relative abundances may also be the result of more fracturing burn patterns of pine and a cultural choice rather than a necessity. The social aspects of selection, planning and adaptability for the accumulation of stored resources for food supplies so important in Pueblo pre-history supports an argument for a managed strategy of fuel collection also. Cushing (1920:638-639) records quantities of stored brushwood for use throughout the year at Zuni Pueblo. Fewkes (1896:20) comments on stored dried branches of shrubs [Hopi]. Using fast growing shrubs and collecting surface litter such as dead branches and needles provides dry, easily combustible and convenient material for fires lessens the workload associated with cutting trees for fuel wood. It is a strategy that avoids removing slow-growing and productive food-source trees and creates a landscape fire prevention strategy that lessens fuel load in dead litter and creates a fire barrier around villages and other habitations. In the dry southwest, the threat of fire due to lightning would have been, as it is today, a major concern. Burning old termite infested beams makes sense and I maintain also serves as an alternative explanation for later tree-ring cutting dates at Sand Canyon Pueblo. The identification of pinyon pine is an important one in this respect especially when inferring resource stress. The use of rose species shrubs in SCP fires suggests that these may have been preferred as much as available. Species such as *Artemisia tridentata* and *Chrysothamnus* are culturally marked in the historic period, associated with medicine, dye, and ceremony. The apparent low visibility of these species in Sand Canyon Pueblo fires may be the result of cultural rules or something as innocuous as burn effects. Both species have ring and pore patterns that cause breakage and quick burn times. They also are likely to degrade more readily over time. *Artemisia* charcoal was found in block 100, 200, 300, 500, 1000, 1200 and 1500 most commonly as vegetative samples in wall and roof fall and collapsed structures or in secondary refuse contexts. A firepit in room 104, a burned spot outside the site-enclosing wall, a corner bin in room 206, the hearth in kiva 1012 and a firepit in the upper storey of kiva 1502's corner room (1527) contained evidence of big sagebrush charcoal. Fewer specimens of *Chrysothamnus* are identified, its internal pore arrangements are wave like in bands that would fragment easily. These were also mostly in wall and roof fall. Secondary refuse/trash accumulations that yielded rabbitbrush charcoal include courtyard 1000, kiva 102, kiva 1004 and peripheral room 1519 in the D-shaped building. Additional sampling and subsampling may shed light on the relative "absence" of these remains in contexts other than building collapse. The presence of these shrubby taxa on roofs may signal deliberate lighting of kiva roofs and other structures but, similar to the culturally proscribed discard of animal bones, may also represent conveniently placed stores of brushwood.

<u>Seeds and the "wild" record</u>. FV14 produced unusual seeds and achenes of *Artemisia tridentata, Atriplex, Polygonum* in addition to *Ephedra* charcoal and stems. *Artemisia* achenes are uncommonly recovered or identified at SCP (seed cache in rectangular kiva 107 is an exception). In Sand Canyon Locality samples, these were found in only two sites at Wood's Canyon Pueblo and Yellow Jacket Pueblo as of this writing. The total abundance of big sagebrush achenes for latter two sites is nine achenes. Presence in the midden in block 1200 suggests that these achenes were either inadvertently discarded as the result of other activity associated with the branches or used as a medicinal strategy as I have proposed for block 100. An alternative explanation is that under sampling and subsampling decreases the visibility of such small specimens, *Artemisia* achenes are likely to sort out into the smallest particle sizes. Previously a single charred *Artemisia tridentata* flowering head was recovered in a vegetative sample for midden 1214, none are recorded previously elsewhere. The abundance of big sagebrush flowering heads in the new sample hints at something different in this midden.

Atriplex achenes are another unusual find. No saltbush seeds have been previously identified in any sample type and are unique to Sand Canyon Pueblo. Saltbush (*Atriplex* sp., *Atriplex canescens*) is documented as being used historically as medicine, food, as a spice or flavouring in addition to its association as one of the four ceremonial kiva fuels (Hough 1897:42). Fewkes (1896:20-21) provides the following information of Hopi use of saltbush of which three species are recognized and named (adapted by me):

> *Atriplex confertifolia*. Known as *hoyavako* from the word *hovaktü* meaning "sweet smells." The water in which the leaves of this plant have been boiled is used to mix the corn meal for making the pudding called *ho-ya-vak-pikinni* (*piki amiyata*, piki or paper-bread, covered in). This meal pudding is poured into a large earthen jar and baked in the characteristic small cooking-pit common in Tusayan [Coconino County, Arizona, across the border with Utah].
>
> *Atriplex argentea*. Known as *üñatki* from the word *üuñña*, salt; *tcoki*, a term applied to an entire tree or plant growing in place. Its salty leaves are boiled and eaten with fat. It is one of the earliest of the six typical Hopi food-plants of spring.

Atriplex charcoal has been identified in sample FV4 from a sealed over firepit in room 1005 near the tower (1008/1019) in block 1000 (see chapter seven, pp. 209-210) and noted for larger sites in the Sand Canyon Locality: Castle Rock Pueblo (133 specimens), the Hedley Site Complex (2 specimens), Wood's Canyon Pueblo (55 specimens) and Yellow Jack Pueblo (9 specimens), most noted in secondary refuse context samples. It might be tempting to associate the use of this shrub with roofing material or as fire starter for post abandonment burning but the context of use at these sites does not suggest that interpretation, rather the evidence suggests other purposes than simply a fuel wood choice. Used in ethnomedicine for the treatment of fungal infections, bronchitis and diabetes, over 270 species of *Atriplex* L. are found in deserts and semi-deserts around the world (Jabrane et al. 2011; Keckeis et al. 2000). Similar to a number of other plant families, *Atriplex* (Chenopodiaceae) contains saikosaponins, elements that are pharmacologically active used in ethnomedicinal applications for the treatment for cancers, infections, and inflammation (83).

The FV14 sample also contained more than 90 stem/twig specimens of *Ephedra*. Previous to this analysis the only evidence of ephedra twigs are the twelve stems recovered in a flotation sample excavated from the open courtyard (nonstructure 1500) outside the D-shaped building, its context of use interesting when considering the properties of the plant. These stems are probably the species *Ephedra viridis* (Mormon Tea) that grows profusely around the village site today. Additional samples (FV15 and FV20) also yielded evidence of *Ephedra* either the stems or charcoal. These samples were collected from refuse in the courtyard of block 1000 (nonstructure 1000) and from refuse in the decorated peripheral room 1513 of the D-shaped building. Additional information about the importance of *Ephedra* is discussed in secondary refuse comparisons 1, 2 and 6 to follow. The presence of the remains in midden/refuse contexts suggests the discard of twigs used as a medicinal tea. *Ephedra* cones in this sample (both female and developing cones) are seasonality indicators. Anderson (2004) places the development of *Ephedra nevadensis* (Nevada jointfir) cones in early March to June situating use in the spring or early summer. Few sites in the Sand Canyon Locality were found to contain *Ephedra* that further indicate contextually specialized use. Six Locality sites are noted for the charcoal: Castle Rock Pueblo (24 specimens), Catherine's Site (two specimens), Lillian's Site (six specimens), Troy's Tower (one specimen), Wood's Canyon Pueblo (ten specimens), Yellow Jacket Pueblo (six specimens)(CCAC 2015b). Based on low specimen counts it is unlikely that *Ephedra* represents a fuel choice but secondary evidence of the use of the plant for other purposes.

Another uncommonly identified seed/achene found in the new sample is *Polygonum* (bindweed). The record for this species is a single bindweed-type achene previously recovered in a flotation sample from primary refuse contexts: the southeast firepit in tower room 1008 and in the east kiva (1502) in the D-shaped building. *Polygonum* is a nonweedy, lower producing plant with very small achenes that may not develop every year (Adams et al. 2007; Table 12). Because of their small size they are expected to sort into the smallest screen sizes where the portions are likely to be subsampled. Outside of Sand Canyon Pueblo only one specimen has been identified (Wood's Canyon Pueblo in a mixed deposit). Little is known about this species historically: Stevenson (1915:58) documents *Polygonum lapathifolium* L. (smartweed) as Zuni *haʹtashawe*, (meaning "long leaf") which was boiled for an emetic and purgative and was a medicine belonging to "all fraternities," hinting at ceremonial usage at SCP also. A similar seed and one that could be mistaken for *Polygonum*, is *Rumex hymenosepalus* Torr. (Canaigre) or *sayaʹvi*, a Hopi word associated with the use of the roots for medicine (Whiting 1939:73). Stevenson (1915:59) also recognizes *Rumex* as a Zuni medicine. *Polygonum* is widely used ethnomedicine and recent pharmacological and phytochemistry investigations point to the efficacy of many species (Nkuété et al. 2015).

The recovery or identification of grass types is also uncommon likely due to problems in identification, fragmentation, size and vulnerability to degradation. Previously the identification of grasses (Gramineae/Poaceae [a newer term]) consisted of a single festucoid caryopsis encountered in a late occupation refuse context, an unknown grass type caryopsis found in a similar late deposit and two stem fragments recovered in earliest and early temporal samples (Adams et al. 2007, Table 14). Indian ricegrass specimens were encountered in two earliest occupation contexts. Five ricegrass specimens have been identified, found in mostly secondary refuse in nonstructural locales, 52 florets of possible ricegrass were recovered in a secondary refuse deposit from the courtyard in block 1000

(CCAC 2015a)(see secondary refuse comparison 1, pp. 308-310, this chapter). The FV14 sample provides more information about grass use. A brome grass (Pooideae)(Adams, personal communication 2009) is also new for the site. Grass seeds, especially Indian ricegrass, were important resources for native groups across North America (see Appendix C). The coprolite record of Pueblo III confirms that grass seeds were commonly consumed. The ethnographic record attests to the fact that this tradition continued into the historic period (Cushing 1920). The identification of types and the size of specimens that likely sort into the smallest particle sized screens makes Poaceae a problematic resource to account for based on size and light fraction sorting effects.

The additional flotation sample from midden 1214 provides a new information about this midden and discard in the later period of occupation at Sand Canyon Pueblo. The wide range of plants paints a picture of subsistence strategies and agricultural productivity that does not support scarcity even in light of changes in how rooms and kivas were used. If the remains from this single new volume reflect a previously untapped standard for middens, under sampling middens and refuse may be the cause. The variety and relative abundance clearly shows that at this point in residency there are abundant resources for food, fuel, and other materials. The same assessment cannot be said for the original volume where genera, species counts and inference values are low. This comparison demonstrates the odds of selecting the most productive sample for a deposit depends on the number of samples excavated and luck of the draw. Additional samples from midden 1214 are documented later in chapter nine.

<u>Midden summary (Table F.4, Appendix F)</u>

Middens are challenging to interpret representing as they do multiple episodes of discard that can obscure temporal and spatial associations. The standout volume, FV14, clearly demonstrates that the original volume examined was not a representative sample of the activities occurring in and around block 1200 in a late occupation context. The location and configuration of the rooms in which the midden was located and the covering over of metate bins hints at social changes in occupation here: the transformation of a center of maize processing into an area for trash certainly suggests new concerns. The abundance and variety of plant remains in new sample suggests that these concerns did not appear to be resource dependent. All data for this section are combined in Table F.4, Appendix F.

Secondary refuse, not further specified

The six trash samples in this section were collected from what would be considered community spaces, the courtyard in block 1000, the great kiva, and the D-shaped bi-walled building and were not designated as formal middens. Estimated temporal deposition ranges from early in the occupation through a period of expansion and transitions. Some samples could be considered from typical discard, occurring prior to shifts in discard behaviour. Others are from what might be termed atypical discard, occurring after changes in the use of important buildings and plazas. Data from all secondary refuse samples evaluated here are presented in Table F.5 Appendix F.

Secondary refuse comparison 1: courtyard 1000

New sample, FV15 (PD 839, FS 145) and its comparison volumes (CV15a and CV15b) were collected from the secondary refuse located under the courtyard surface ("level 3") of courtyard 1000 (p. 212)(CCAC 2004: Extramural Surfaces, Nonstructure 1000). Described as consisting of ash alternating with layers of red-brown sand, the accumulation contained charcoal, blackened clay and artifacts. Based on stratigraphic placement, I estimate the remains recovered from the samples here were deposited prior to the building of the courtyard surface that occurred around A.D. 1266, placing deposition in a timeframe associated with the development of great kiva peripheral rooms and the early construction of block 1500. The samples which were deposited below several surfaces could represent early activities prior to the courtyard surface construction capturing evidence associated with an initial ideological period of SCP occupation occurring sometime around the A.D. 1250s. All samples are from the same location and stratum. Data are noted in Table E.15, Appendix E.

FV15 was 1000 ml pre-flotation volume and yielded 194 ml of light fraction. I scanned 85.1 ml, subsampling the .71 and .25 mm portions and examining all the material in the 1.4 mm screen because of manageable sediment in this portion. Sample CV15a (PD 839, FS 144) measured 850 ml, CV15b (PD 839, FS 148) measured 1000 ml pre-flotation, both are referred to collectively as "volume 1," and all data combined for comparison purposes. Similar to FV15, these samples contained what would be considered high volumes of light fraction. CV15a produced 113 ml in total of which 102 ml was originally examined. CV15b measured 134 ml of light fraction and 103 ml was examined.

Original findings: CV15a, CV15b ("volume 1")

"Volume 1" provides the most information in this comparison. *Juniperus* and *Pinus* charcoals were identified in both samples. *Pinus edulis* cone scales were identified in CV15a. Shrubby taxa consist of *Amelanchier/Peraphyllum*, *Artemisia tridentata*, *Cercocarpus*, *Chrysothamnus*, *Fendlera*, and *Purshia*. *Zea mays* evidence includes cob fragments, cupules, and kernel fragments suggesting the use of maize for both food and as a fuel material. Seeds of cheno-am, *Portulaca retusa*, and a significant quantity of *Oryzopsis hymenoides* (52 specimens) were identified, although this identification is noted to be "questionable." An unidentified fruit and seed are recorded (Table 8.17, over).

Table 8.17 Suggested inference potential: secondary refuse comparison 1 (charred remains).

Interpretive Category	Volume 1 (CV15a)	(CV15b)	New volume (FV15)	New taxa[a]
Foods				
Domesticates (FD)	*Zea mays*	*Zea mays*	*Zea mays*	-
Wild resources, weedy (FW)	Cheno-am	-	-	-
	Portulaca retusa	-	-	-
	Oryzopsis hymenoides‡	-	-	-
Wild resources, nonweedy (FN)	-	-	-	-
Wild resources, other (FO)	-	-	*Ephedra*	*Ephedra*
Fuels				
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	*Juniperus*	-
	Pinus	*Pinus*	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	-	*Amel/Pera.*[b]	*Amel./Pera.*[b]	-
	A. tridentata[c]	-	*A. tridentata*[c]	-
	Cercocarpus	-	-	-
	-	*Chrysothamnus*	-	-
	Fendlera	-	-	-
	-	*Purshia*	-	-
	-		*Prunus/Rosa*	*Prunus/Rosa*
Zea mays cob remains (FLZ)	*Zea mays*	*Zea mays*	-	-
Tinder type (FLT)	*Pinus edulis*	-	-	-
	Pinus	*Pinus*	*Pinus*	-
	-	-	*J. osteosperma*[d]	*J. osteospermad*
Other				
Other, ecological (OE) [seasonality]	Cheno-am [summer]	-	-	-
	Portulaca retusa [summer]	-	-	-
	Oryzopsis hymenoides [spring]‡	-	-	-
Other, unknown (OU)	Fruit	-	-	-
Other, worked (OW)	-	-	-	-
Genera/species count (CV15a and b combined)		**13**	**8**	**3**
Inferred interpretative value (CV15a and b combined)		**19**	**9**	**4**

Notes:

[a] Number of taxa based on interpretive categories representing new information contributed by the additional sample.

[b] *Amelanchier/Peraphyllum*.

[c] *Artemisia tridentata.*

[d] *Juniperus osteosperma.*

‡ Identification "questionable."

New findings: FV15

FV15 contained similar quantities of *Juniperus* charcoal. A number of *Pinus* bark scales in addition to *Pinus edulis* charcoal were observed. A single *Juniperus osteosperma* scale leaf is interpreted as evidence of tinder material although ethnobotanical records indicate its use as medicine. Shrubs include *Amelanchier/Peraphyllum*, *Artemisia tridentata*, and *Prunus/Rosa*-type charcoal. A fragmented *Zea mays* kernel was recovered. Wild food-type resources are limited to evidence of an *Ephedra* twig and stem fragments.

Thirteen genera/species (including pinyon pine) are represented in the original samples. Two genera are added with the new volume, charcoal from *Prunus/Rosa*-type and *Ephedra* stems/twigs. The additional sample is important for this species, which is likely *Ephedra viridis* Cov., or Mormon tea, native to the Dolores and Montezuma counties of Colorado (Heil and O'Kane Jr. 2005:8). Evidence of *Ephedra* in more abundance in trash contexts suggests more widespread use at Sand Canyon Pueblo than elsewhere in the area. Ephedra contains significant quantitites of the compound ephedrine and contemporary clinical trials have shown the plant to be an effective analgesic, antifungal, anti-inflammatory, antipsoriatic, antitussive, hypertensive and hypotensive (Ross 2001:131-135). Culturally *Ephedra* is a specific cultural artifact with a well-supported ethnographic use in the treatment of treponemal disease that enhances the interpretation of this sample. It is likely that the ancient Puebloans also saw evidence of antibiotic or other positive health effects. The treatment of treponemal disease today requires high doses of antibiotics for resolution and the use of *Ephedra* may have resolved this issue.

The 52 specimens of Indian ricegrass identified for the original samples, although questionable identifications, suggests that grass seeds were an important food source at SCP confirmed by typical Pueblo III diet (Minnis 1989; Sutton and Reinhard 1995). Counts such as this are considered relatively significant and, if not ricegrass, certainly the quantity speaks to a careless discard of another edible grass type. Based on the inferred estimated time frame of courtyard use here, these materials were sealed over with a courtyard surface. Indian ricegrass specimens are encountered in deposits associated with abandonment contexts also. No documented faunal remains are identified for the deposit and so no general food economy can be suggested. There are, however, nine unprocessed flotation samples from this context archived should further analysis be considered.

<u>Secondary refuse comparison 2: plaza 1500 surfaces outside west kiva, D-shaped building</u>

Two samples are compared for courtyard 1500. Situated outside the west bi-wall of the D-shaped building, the deposit was a compacted layer of refuse under several cultural surfaces. The location is important for its connection to this unique structure and in close proximity to a deliberate and careful burial of a dog near the entryway to the bi-wall rooms that encircle the west kiva. The west kiva (structure 1502) is notable for its construction date of circa A.D. 1270, a date approximately ten years after the construction of the bi-wall rooms and the east and more elaborate kiva (chapter seven, pp. 219-220). The samples were collected from one of two test trenches that butted up against the outer curved wall immediately in front of the floor-level doorway and the burial. The deposit also bordered the open area to the north of the building that was interpreted to be an associated plaza (CCAC 2004, Cultural Deposits, Nonstructure 1500). The refuse was deposited during the period of more elaborate construction.

Samples FV16 and CV16 were collected from the third stratum below a cultural surface (surface two) of the plaza outside the west entryway to the D-shaped building one surface and two strata below and in the general vicinity of the deliberate dog burial. The third stratum consisted of small pieces of sandstone, artifacts, naturally deposited sediments that accumulated and compacted over time (CCAC 2004, Cultural Deposits, Nonstructure 1500). Among other artifacts, a turquoise bead was located in this area. The abundance of plant remains scattered through multiple layers is impressive, much of it uncharred. Latest episodes of discard here include evidence of domesticates (*Cucurbita* seeds and *Zea mays* cob fragment). Numerous uncharred *Pinus* nutshells were noted in vegetal samples below wall fall and modern ground surface. Vegetal samples from the same strata were identified as *Juniperus*, *Pinus* and Rosaceae-type charcoal, uncharred *Pinus* nutshells, and uncharred *Juniperus* seeds. Even earlier layers (below another surface) yielded evidence of *Juniperus*, *Pinus*, *Prunus/Rosa* and *Ephedra* charcoal and a relatively large quantity of *Juniperus* (likely *J. osteosperma*) twigs (67 specimens). Domesticates include *Zea mays* (kernels, cob segments, cupules) and Cucurbitaceae (rind). Seeds of cheno-am, *Opuntia*, *Portulaca*, *Physalis longifolia*, and *Oryzopsis hymenoides* were recovered in a single flotation sample. Grass stems were noted. These early trash accumulations suggest that typical Pueblo III domesticates and wild resources were discarded in this location, likely prior to the construction of the D-shaped building, making the content comparative for later deposits. Table E.16 (Appendix E) summarizes light fraction recovery.

Originally new sample FV16 measured 750 ml in pre-flotation volume and yielded 39.5 ml of light fraction. I subsampled the .71 and .25 mm portions only due to abundance of retained sediment in these screens for a total volume examined of 17.5 ml. FV16 is compared to a 500 ml sample (PD 1124, FS 184) now called CV16 (“volume 1”) from the same context and provenience. This sample yielded 36 ml of light fraction and 26 ml was originally examined. Subsampling was presumably imposed for the same reason as I did, abundant sediments in the smaller screens or, the bulk of sediments accumulated in the catchpan (<.25 mm), which is typically unexamined. All data collected for both samples are presented in Tables 8.18 (p. 313)and E.16 (Appendix E).

Original findings: CV16

Charcoal remains were identified as *Juniperus* and *Prunus/Rosa*-type. Over 50 specimens of *Juniperus* (likely *J. osteosperma*) twigs and scales leaves were counted. *Zea* mays cupules suggest the remains of cobs used for fuel material. Wild resources included seeds of cheno-am, *Opuntia*, *Physalis longifolia*, and *Oryzopsis hymenoides*. A quantity of *Ephedra* stems is accounted for in this sample, similar to *J. osteosperma*, in unusual abundance. For the most part these genera/species are absent in the additional volume.

New findings: FV16

Charcoal remains consist of *Juniperus, Pinus edulis,* and *Amelanchier/Peraphyllum*. I found no evidence of charred *Juniperus osteosperma* or remains of *Ephedra*. Charred seeds include *Amaranthus* and the less specific cheno-am. Uncharred seeds of *Mentzelia* and *Sisymbrium/ Descurainia* and *Artemisia* (flowering head), *Juniperus osteosperma* (twigs) and *Pinus edulis* (needle) were also recovered and may represent ancient material. The sample contained many small bone fragments. Uncharred (presumed modern) fiber likely came from accidental contamination during excavation. A charred *Hesperostipa comata*-type (also documented as *Stipa comata*) or needle-and-thread grass is a new species for Sand Canyon Pueblo although it is abundant around the site today. The only record of the species in the Sand Canyon Locality is one specimen recovered in a flotation sample from an unspecified cultural deposit at Yellow Jacket Pueblo.

Ten taxa are accounted for in the original sample contributing 14 inferences of use and seasonality based on interpretative categories. With an additional flotation sample four new taxa and six new inferences of use and ecology provide further support for spring and summer deposition. The bulk of the remains from FV16 are uncharred reflecting either excellent preservation, excavation effects or other disturbance. The timing of deposition is of considerable inference value particularly in the D-shaped building.

<u>Timing</u>. Both samples in this comparison were collected from refuse that accumulated circa A.D.1260 and prior to any significant shifts in behaviour we see later in the transition to more residential activities. The expectation is that the plants reflect something of typical activities occurring during a phase that was associated with the original purpose of the east kiva. As an elaborated space with unique architectural features, the original east kiva activities had a ceremonial, ritual or group focused components. The seasonality of plant remains recovered in these samples indicates deposition from spring to fall or a combination of stored resources. The most unique plant remains are those historically associated with traditional medicinal or curing practice: *Ephedra, Juniperus osteosperma* twigs and uncharred remains of *Mentzelia* and *Sisymbrium/Descurainia* known for their pharmacological activity. The tradition of secret clan knowledge of “medicines” in mythic, historic and contemporary narratives suggests that medicine is a broader conceptual category that assures the mitigation of not only physical disease but also spiritual and environmental conditions through ceremony, the product and the metaphor “owned” by particular groups (Cushing 1920; Parsons 1996 [1939]; Stevenson 1915; Whiteley 1998).

Suggested inference values for these samples are outlined in Table 8.18 (over).

Table 8.18 Suggested inference potential: secondary refuse comparison 2 (charred remains).

Interpretive Category	Volume 1 (CV16)	New volume (FV16)	New taxa[a]
Foods			
Domesticates (FD)	-	-	-
Wild Resources, weedy (FW)	Cheno-Am	Cheno-am	-
	Physalis longifolia	-	-
	Oryzopsis	-	-
	hymenoides	*Amaranthus*	*Amaranthus*
	-	*Stipa/Hesperostipa comata [?]*	*Stipa/Hesperostipa comata [?]*
Wild resources, nonweedy (FN)	*Opuntia*	-	-
Wild resources, other (FO)	*Ephedra*	-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Prunus/Rosa*	*Prunus/Rosa*	-
	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
Zea mays cob remains (FLZ)	*Zea mays*	-	-
Tinder types (FLT)	*Juniperus osteosperma*	-	-
	Pinus	*Pinus*	-
Other	-	-	-
Other, ecological (OE)	Cheno-am [summer]	*Amaranthus* [summer]	-
[seasonality]	*Physalis longifolia* [fall]	-	-
	Oryzopsis	-	-
	hymenoides [spring]	*Stipa/Hesperostipa*	*Stipa/Hesperostipa*
	-	*comata* [spring]	*comata* [spring]
Other, unknown (OU)	*Ephedra*	*Stipa/Hesperostipa comata*	*Stipa/Hesperostipa comata*
Other, worked (OW)	-		-
Genera/species count	**10**	**8**	**4**
Inferred interpretative value	**14**	**11**	**6**

Notes:

[a] Number of taxa based on interpretive categories contributed by the additional sample.

[?] Food use presumed. Historic records indicate a ritual use for this species.

The D-shaped building with its unique configuration and unusual faunal assemblage also contains unusual plant remains. Unique to the building is needle-and-thread grass awn fragments found in the new sample here and in a new sample collected from below the plaza surface outside the west entry (comparison 5, sample FV19). Although a spring season resource, this grass has an historic link to ceremony, specifically the November *Wuwuchim* ("New Fire") or men's initiation ceremony that marks the beginning of the ceremonial period of the year (Courlander 1971:239; Parsons 1996 [1939]:497). This event is the most important in terms of men's status for the Hopi; initiands come from other villages to be accepted into one of four major men's societies. Like Katsina ceremonies, *Wuwuchim* is tied to kivas (Adams et al. 2004:129-131). Colton (1974: 367) documents *Stipa neomexicana* (Thurb. Ex Coult.) Scribn. (New Mexico needlegrass) as a plant used in the making of necklaces worn by the first initiates of *Wuwuchim*. Whiting (1939:66) documents the Hopi word for

Stipa comata Trin. & Rupr. (needle-and-thread grass) as *ho:ʼki* although no translation of the word is suggested.

Faunal and cosmological evidence. Plaza 1500 includes the uncommon remains of *Buteo* sp. (hawks), Canidae (dogs and wolves), *Canis* sp. (dog/wolf/coyote), *Canis familiaris* (dog), Corvidae (jays and crows), *Corvus corax* (raven), Falconiformes (vultures/hawks/eagles) and Passeriformes (perching birds), remains notable for their cultural importance. The assemblage also includes deer sized ungulates, fox sized mammals, jackrabbit, cottontail, an abundance of turkey (CCAC 2004: Cultural Deposits: Nonstructure 1500: Animal Bone Analysis Summary; Muir 1999, 2007) testifying to food eaten in the building. Muir (2007) notes that the unusual remains of birds and large mammals are significant for their ritual significance rather than strictly as food values, particularly Pueblo spiritual themes associated with birds of prey. Examples include the Zuni connection of turkey, duck, hawk and eagle with the dead; turkey and duck with the rain cult, hawk and eagle with war or leadership (Parsons 1996 [1939]: 275-276). The feathers of birds are also associated with the colours of the six cardinal directions (275)(see Table B.1, Appendix B here). Dove, hawk, chimney swallow were the "bird scouts" of the underworld in Hopi cosmology: the Lakon or eagle society sends up Dove to look for the sipapu to the fourth world (237). The Hopi Mockingbird sings songs "still sung" at the ceremony at Oraibi (239).[102] Although *Canis* remains are recovered in other architectural blocks

[102] Some culture history: Oraibi/Orayvi, is located on Third Mesa, northeastern Arizona, and was one of the two largest Hopi villages occupied during the A.D. 1300s and continued to be so until early 1700s (Adams 2004:126). Orayvi room counts are estimated to be 100 in the A.D. 1200s, increasing to 200 by 1250. By A.D. 1300 another 100 rooms were added. The mass migration out of the Mesa Verde region around the same time (late 1280s and 1290s) corresponds to increased village size on the Mesas (Varien et al. 1996). Located approximately 300 km from Sand Canyon, it is a reasonable distance of travel (see Hough 1897). Parsons' (1996 [1939]) ethnographic work with the Hopi which occurred between 1916 and 1932 (Strong 1996) captured not only a record of traditional ceremony and cosmology there, but also she would have seen the effects of a factional split and warfare at Orayvi in 1906 and 1907. During that particularly difficult time, Orayvi saw changes in architectural configurations that are suggestive. Cameron (1992) argues that social patterning is reflected in the shifting use of buildings and the re-use of buildings that fell into disuse at Orayvi, the factional split demonstrating social and spatial household patterns and population movement linked with Hopi matrilineal residence patterns. Prior to the split, spatial organization of occupied houses reflected clan affiliations. The 1906 abandonment of houses by what are termed "hostile" families led to slow dismantlement of useable wood, doors and masonry, and a rebuilding phase that focused on the western end of the village where homes were then reoccupied by "friendly families," refurbished and reused. This was particularly evident in important ceremonial areas such as the Main Plaza and Snake Dance Plaza (179). Cameron goes on to suggest that this partial abandonment, likely a common response, demonstrates household or alliances among households taking precedence over clan in the historic period, the clan being the more important social unit prior to that time. The dismantling of homes at SCP and the reuse of structures not so uncommon when considering the Orayvi split and shifts in building uses. The re-use of materials then not entirely unexpected, reflecting a cultural not necessarily environmental, response. The shift in behavior so apparent in later occupation times at Sand Canyon Pueblo is similar in respects to historical responses to the development of factions at Oravyi. Re-using space and re-purposing resources are documented adaptation to social challenges and at Orayvi we see a shift in alliances between clans and lineages (Cameron 1992). The historic record of Hopi villages offering clues as to contributing factors that may have been in play in the reconfiguration of the Sand Canyon occupancy prior to the final catastrophic events.

that yielded evidence of *Canis* sp. bone tools, no area has the concentration of such remains as the D-shaped building. The early careful deliberate dog burial at the entryway to the building, the almost complete skeletons in bi-wall rooms 1510 and 1513 shows that the dog/wolf/coyote connection may have had important ritual significance here (Muir 1999, 2007). Even in late deposits these remains do not suggest simply a food strategy but, in this context hint at a metaphoric strategy, one that shares links with the mythic period and the association with the east and the wolf as drawn on the east wall of the Warrior Room at Walpi (Fewkes 1902, plate XXII). Fox remains in the east kiva (and fox-sized remains elsewhere) may hint at a food strategy although the fox skin of the Bow Priest as he ascends the ladder in the grey dawn of morning is suggestive of ceremonial leaders and sun watchers on the rooftops of historic kivas as proposed by Ortman and Bradley (2002:61). The ethnographic significance of wild resources recovered in both samples evaluated for this comparison provides an opportunity to explore the function of the D-shaped building as somehow "different" using plant data and local knowledge to support, as per Whiteley (1998:13) a local theory of *artifacts* applied to the archaeological evidence. Kiva 1502 also contained the mandible of a civet/ringtail cat (*Brassaricus astutus*) harkening to the wildcat mural on the south wall of the Warriors' Room at Walpi Pueblo (Fewkes 1902). The historic clan association with the south direction indicates a connection with the Badger clan (Parsons 1996 [1939]; Whiteley 1998). The mural cat is accompanied by a drawing of a concentric circle with a central star. A similar ideogram is found above the firepit in tower 101.

I initially categorized the east kiva 1501 as the *civet cat kiva* as a way of thinking about its possible connections to historic records of Pueblo religion. The consistencies between unusual animal remains at Sand Canyon Pueblo may or may not be food or "recent," but rather ceremonial and identifiers. The cosmological associations that match so well with the archaeological remains are more than simply coincidence. The underlying metaphor of Pueblo cosmology allows for a more complex explanation of the occupation. First and foremost, directional cues and identity are significant.

<u>Revisiting *Amaranthus*</u>. Historic linguistic differences and use distinctions demonstrate possible meanings for ancient *Amaranthus* and *Chenopodium*, *Amaranthus* is most associated with ceremony. It is possible that ancient *Amaranthus* seeds are similarly situational, associated with the making of bread and the colouring of it or the use of the plants for face paint in the historic period (Tables 8.10 and 8.11, pp. 282-283, this chapter). I identified *Amaranthus*-type seeds in samples from a courtyard firepit, a kiva hearth (kiva 1010 unknown type), midden 1214 refuse, and in the D-shaped building. The coprolite evidence of *Amaranthus* suggests this species was part of a typical Pueblo III consumption (Reinhard 2006), although this evidence would also be situational. As is the case with many unusual plants, the historic record suggests that certain species are ingested as medicine.

“Ethnographic” *Ephedra*. A review of *Ephedra* use helps to reaffirm the importance of the plant to historic groups and contextual similarities at SCP. The historic Hopi recognize two varieties of the Mormon tea family. *E. torreyana* S. Wats. (Torrey’s jointfir) and *E. viridis* Coville (Mormon tea). These are distinguished linguistically as *masi″’*$_3$*′svi* meaning “gray,” *E. torreyana* and *’*$_3$*′svi* meaning *E. viridis* (Whiting 1939:63-64). The preference is Torrey’s jointfir although no explanation was given. Both species were used for their medicinal properties. The Zuni recognized and used *Ephedra nevadensis* S. Wats. (Nevada jointfir/Teamster’s tea), naming it *tsi′posho* meaning “stiff-jointed,” due to its jointed and upright stems/twigs. It is a plant medicine that Stevenson (1915:49) records as belonging “to all the people.” With the exception of the root, all parts of the plant were used as a beverage. No symbolic association is recorded for *Ephedra,* such as clan names or colour symbolism. However, the plant’s pharmacological potential suggests that it is medically situational and part of a body of knowledge. In this regard, *Ephedra* remains in a ceremonial context are not unexpected. Prior to the additional samples evaluated here, stem remains were recovered only in the original sample for this deposit (approximately 12 specimens). One other specimen, a worked stem with a pointed end was found in a vegetal sample associated with midden 1214. *Ephedra* charcoal was recovered for the most part in vegetal samples where approximately 29 specimens were identified (CCAC 2015a), fifteen of which were recovered in trash contexts (midden 1214 and in nonstructure 1500, this sample comparison). The remaining specimens were collected from a storage room firepit (structure 104), the roof fall of a storage room (structure 206), the great kiva (three specimens) and in structure 812 where five specimens of charred wood were identified.

Oryzopsis hymenoides. In addition to the D-shaped building evidence, Indian ricegrass was recovered in quantity in sample FV2 from a burned spot located in room 1003 (a large room associated with the D-shaped tower in block 1000). Known historically as Indian millet, Whiting (1939:46) makes the following observations of Hopi clans and plants such as Indian ricegrass:

> Hopi clans are old and some of the objects for which they are named are no longer as important as they once were. Thus the Indian Millet Clan [*le:’hu,* or *Oryzopsis hymenoides*] is named for a grass that was once an important source of food. The Reed, Oak, and Greasewood Clans are named for plants once important in the manufacture of weapons for hunting and war.

The courtyards in blocks 500, 1000 and 1500 and roof fall collapse in block 1200 are all noted to contain Indian ricegrass specimens. New samples from the hearth in kiva 1010 and midden 1214 also contained the seeds. This species is uncommonly identified in samples from Sand Canyon Locality sites as well: Castle Rock Pueblo (CRP)(53 specimens, 50 from a sample collected from CRP tower 401 that also contained Malvaceae, *Mentzelia albicaulis* and *Ephedra*, an interesting combination of pharmacologically active plants), Stanton’s Site (three specimens), Wood’s Canyon Pueblo (two specimens) and Yellow Jacket Pueblo (18 specimens)(CCAC 2015b). The size of Indian ricegrass specimens is small enough that subsampling could impact recovery. The seeds are routinely found in coprolites dated to the Pueblo III period (Sutton and Reinhard 1995). As a category of “ancient” food with clan associations the species holds or held significance, at minimum as a culturally important food.

In this comparison, both samples contribute plant evidence that is not commonly accounted for in flotation samples. There remains 500 ml of unprocessed and archived sediment that might shed additional light on the discard of plants for the D-shaped building and the plaza area outside the west entry. Sample comparisons 4, 5 and 6 provide additional information.

<u>Secondary refuse comparison 3: great kiva</u>

Samples compared for the great kiva consists of two volumes collected from trash that reflect a behavioural shift and the deposition of trash in what was, at one time, an important communal space. This situates the general time frame of deposition late in the occupation, circa late A.D. 1270s, a period most associated with the onset of drought and inferences of resource stress. The expectation is that an additional sample may enhance insight into the use of plants in this period of “disorder.”

Flotation sample FV17 (PD 1091, FS 17) was collected from an ash deposit located near a bench in the great kiva on a second prepared surface (on or near the latest floor)(chapter seven, p. 205). The trash was found near the kiva bench on a prepared surface. The accumulation was uncovered below modern ground surface, wall fall and a stratum of naturally deposited sediments (CCAC 2004 Kivas, Structure 800). The 8 cm to 10 cm thick deposit overlays a lower layer 6 cm to 10 cm thick that may or may not be construction fill. The refuse could not be dated. Trash inside the great kiva suggests that the users were not concerned about waste disposal inside what was once a large and presumably important community structure. The construction sequence for the peripheral rooms is estimated to have continued into the early A.D. 1270s, indicating that the great kiva transitioned in use after this time. The refuse could reasonably be estimated as accumulating as part of this trend. It is also possible that attackers or others discarded trash in such haphazard places after the final warfare event, if they remained or others came later, keeping in mind that this would require sufficient time to accumulate obvious refuse and to occupy a space in the presence of what could only be brutalized human remains.

The sample measured 1000 ml prior to flotation and yielded 34.5 ml of light fraction. I examined 26.2 ml subsampling the .71 and .25 mm portions due to retained sediment volume in these screens but reviewed the total volume of the 1.4 mm screen. The data are compared with a previously analyzed 1000 ml sample from the same surface and stratum now referred to as CV17/“ volume 1,” (PD 1091, FS 18). CV17 yielded 23 ml of light fraction and 21 ml was examined in the original analysis. No record of the distribution of the light fraction volume is available. It is presumed that the analyst faced a similar problem of abundance of extraneous material in the smallest screen sizes and applied the SAC approach much as I did, or, the unexamined portion reflects sediments in the catchpan that typically are unexamined. All data collected from these two samples are documented in Table E.17 (Appendix E).

Original findings: CV17

Specimens identified in this original sample consist of *Juniperus*, *Acer* (maple), and *Populus/Salix*-type charcoal and a single *Pinus* bark scale. There is a large quantity of maize cupules (50 specimens) suggesting the burning of cobs for fuel. Wild food resources consist of cheno-am, *Physalis longifolia*, and a grass caryopsis (unidentified type). The original analyst noted several fruit rind fragments.

New findings: FV17

This sample yielded additional charcoal: *Juniperus*, *Pinus edulis*, *Artemisia tridentata*, *Amelanchier/Peraphyllum*-type and a single *Juniperus osteosperma* twig. More variety of *Zea mays* parts was recovered consisting of cob fragments, cupules, glumes, and kernel fragments. I categorize an unidentifiable grass stem fragment as “Poaceae type A” based on distinctive surface features in order to distinguish the various grass stem types found in other samples (Appendix C), photographs D.36 and D.37, Appendix D). This sample contributes new genera and species, new parts and new information. As an accumulation in the great kiva, the remains are important for interpreting activities and discard that presumably reflect a more mundane use of the structure that apparently occurred in the A.D. 1270s.

The original sample produced eight taxa and potentially eleven inferences based on the original goals of analysis. The additional volume contributes five new species/genera and an additional six inferences. The value of the new volume lies in the quantity and quality of maize parts representative of food remains, most notably ground maize. More fuel types are also observed. Neither volume supports differential use of the great kiva versus any other secondary refuse accumulation reviewed to this point. Evidence of glumes and kernel fragments indicates that maize was ground and discarded in the great kiva in a period associated with drought. Combined with wild seed evidence recovered in the initial sample, this supports an interpretation of a milled maize cuisine, one that Sutton and Reinhard (1995) interpret as a pre-harvest food. The discard of ground maize and other refuse in the great kiva supports the interpretation of a change in how the great kiva was perceived. An outline of potential inference values is suggested in Table 8.19.

Table 8.19 Suggested inference potential: secondary refuse comparison 3 (charred remains).

Interpretive Category	Volume 1 (CV17)	New volume (FV17)	New taxa[a]
Foods			
Domesticates (FD)	-	*Zea mays*	*Zea mays*
Wild resources, weedy (FW)	Cheno-Am	-	-
	Physalis longifolia	-	-
	Poaceae	-	-
Wild resources, nonweedy (FN)	-	-	-
Wild resources, other (FO)	-	-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Acer*	-	-
	Populus/Salix	-	-
	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
	-	*Artemisia tridentata*	*Artemisia tridentata*
Zea mays cob remains (FLZ)	*Zea mays*	*Zea mays*	-
Tinder types (FLT)	*Pinus*	*Pinus*	-
		Juniperus osteosperma	*Juniperus osteosperma*
Other			
Other, ecological (OE)	Cheno-am [summer]	-	-
[seasonality]	*Physalis longifolia* [fall]	-	-
Other, unknown (OU)	Fruit rind	Poaceae (type A)	Poaceae (type A)
Other, worked (OW)	-	-	-
Genera/species count	**8**	**7**	5
Inferred interpretative value	**11**	**9**	6

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.

Other evidence may explain the "absence" of plant remains. The great kiva is thought to have lacked a roof and less than ideal preservation conditions could contribute to an apparent absence of food remains. The original sample ostensibly reflects an absence of maize that could be attributed to poor maize production and drought conditions although lack of maize may also be result of a number of other factors. Lack of kernels could be the result of animal predation in this exposed location, reflect that edible corn is in short supply, or simply no one was cooking or working with corn kernels in the great kiva. It may simply reflect pre-harvest conditions for that year.

The wild seed record from great kiva "transitional" trash as documented here still contains what appears to be Sand Canyon Pueblo staples—the cheno-am, grass seed, and common groundcherry also seen in early occupation trash associated with the D-shaped building's plaza. As for the faunal remains, only a fragment of a bone from a cottontail rabbit was located in the bench fill and a single unidentifiable nonhuman bone associated with the same surface in this refuse. An informal firepit located in the south-central portion of the kiva uncovered in an excavation unit contained evidence of *Portulaca retusa*, cheno-am, *Physalis longifolia*, *Zea mays* cupules, and a cob segment. A single specimen of charred *Amelanchier/Peraphyllum* wood was identified. The firepit content is consistent with the trash assessed. Again, the absence of edible maize may also due to the use of ground corn. No additional flotation samples for this accumulation are available.

<u>Secondary refuse comparison 4: lower storey east bi-wall room 1507, D-shaped building</u>

This comparison takes into account activities that occurred in the lower storey of a bi-wall room located on the east side of the building in close proximity to the east and more elaborate kiva (structure 1501; page 217-218). Two samples were compared for the refuse accumulation coming from two different temporal contexts. One sample appeared to be deposited as a result of "typical" D-shaped building activities, that is, prior to any obvious shifts in behaviour in this location. The other I estimate reflects a transition in use of the room, capturing nontypical behaviour occurring prior to the final catastrophic end of the occupation. Using building sequences, estimated dates and stratigraphic placement this situates the content within a decade/key event scheme spanning the early A.D. 1260s to the 1270s. The room is notable for its abundant plant impressions of twigs, corncobs and grass-like materials. All data collected is summarized in Tables 8.20 (p. 321) and E.18 (Appendix E.)

New flotation sample, FV18 (PD 1055, FS 4), the "later" sample, may possibly have measured as much as 1500 ml in volume. It was collected from a trench segment located in this lower storey storage room (structure 1507) from a layer below wall fall in a layer of refuse that accumulated likely after the transition of the room occurred from its original purpose to one of disorder. The room was partially excavated. Beam sockets at less than one meter in height from the floor were interpreted to be the supports for a low ceiling, similar in height to the D-shaped tower room 1008. There were at least two surfaces in this unusual room. FV18 was collected from a surface apparently used late in the occupation (surface 2, stratum 3). The sample yielded 153.5 ml of light fraction and I examined 80 ml, reviewing the 1.4 mm portion because of low sediment volume and subsampling the .71 mm and .25 mm screens. FV18 is compared to a 750 ml sample collected from an earlier use surface (surface 3, stratum 7) in the same trench segment (CCAC 2004: Rooms, Structure 1507). This sample, CV18/"volume 1," (PD 1064, FS 18) was located below two earlier cultural surfaces and the contents of the sample are inferred to capture evidence of the earlier use of the building, prior to changes in use. The sample produced 43 ml of light fraction and 26 ml was examined, presumably subsampled. Despite the difference in interpreted temporal framework, CV18 is interesting that it contains a similar assemblage although with less variety than the later sample.

Original findings: CV18

CV18 contained non-shrubby fuel wood consisting solely of *Juniperus* charcoal. Shrubby fuel types include *Amelanchier/Peraphyllum*, *Prunus/Rosa* and *Quercus* charcoal. No evidence of domesticates or wild food resources were identified.

New findings: FV18

Juniperus and a quantity of *Pinus edulis* charcoal were present in the second volume. Three additional shrubby plants, *Cercocarpus*, *Chrysothamnus* and *Purshia* charcoal are identified. One *Zea may* cob fragment and one segment suggests the burning of maize cobs for fuel. I observed no evidence of reproductive parts other than a thick nutshell fragment (not pinyon). Inference value are suggested in Table 8.20.

Table 8.20 Suggested inference potential: secondary refuse comparison 4 (charred remains).

Interpretive Category	Volume 1 (CV18)	New volume (FV18)	New taxa[a]
Foods	-	-	-
Domesticates (FD)	-	-	-
Wild resources, weedy (FW)	-	-	-
Wild resources, nonweedy (FN)	-	-	-
Wild Resources, other unknown (FO)		Nutshell	Nutshell
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*	-
	Prunus/Rosa	-	-
	Quercus	*Quercus*	-
	-	*Cercocarpus*	*Cercocarpus*
	-	*Chrysothamnus*	*Chrysothamnus*
	-	*Purshia*	*Purshia*
Zea mays cob remains (FLZ)	-	*Zea mays*	*Zea mays*
Tinder types (FLT)	-	*Pinus*	*Pinus*
			Continued…
Other	-	-	-
Other, ecological (OE) [seasonality]	-	-	-
Other, unknown (OU)	-	-	-
Other, worked (OW)			
Genera/species count	**4**	**9**	**6**
Inferred interpretative value	**4**	**10**	**7**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.

The original sample provides four genera and four inferences of use. Six new taxa and seven potential inferences were added with the analysis of an additional sample from this deposit. The two samples produced information that suggest that this accumulation is limited to fuel remains in a room that was interpreted to have been once used for storage, perhaps for that purpose. Four definitive surfaces were identified in room 1507, each containing several distinct strata, the lowest prepared surface, surface 4 overlain by four additional strata contained evidence of sticks, twigs, disintegrated corncobs, grass-like plant remains and a squash seed. Many impressions of sticks, leaves and corncobs were noted in the fill. This refuse was sealed with surface 3 (the provenience of the earlier sample, CV18) and it too contained strata with disintegrated twigs and impressions of twigs and "shelled" corncobs (CCAC 2004, Rooms, Structure 1507). A further floor (surface 2) sealed this refuse and above this surface the new sample was collected. No indication of twigs or corncob impressions is noted here and the refuse that accumulated here was overlain by two strata of wall fall, another prepared surface (surface 1), indeterminate fill and collapsed structural fill. Based on the finding it appears that room 1507 served as a specific storage area for fuel supplies and later used for refuse overlain with a final surface. It is important to note that plants burned in this room did not represent the burning of the structure after abandonment. Faunal evidence associated with the new sample in this comparison consisted of cottontail, large birds, deer, raven and other unidentified fragments. No evidence of faunal remains is documented for surface 3, the lower surface (CV18). What is clear is that the room once served as a space for the storage of shrubby fuel material much as described in the ethnographic literature (Cushing 1920:638-639; Fewkes 1896:20; Whiting 1939:74). Later fauna suggest a ceremonial or ritual component possibly associated with special activities in the east kiva.

<u>Secondary refuse comparison 5: east bi-wall room 1511, D-shaped building</u>

Located in close proximity to room 1507 and the east kiva, bi-wall room 1511 contained material thought to have accumulated after the original use of the room ceased, sometime after A.D. 1268 (CCAC 2004: Rooms, Structure 1511). Later dates for the construction of the west kiva and its multiple re-surfacing projects, confirm continued use of the building for its original purpose for some time. If the dates for the initiation of the west kiva (1502) are accurate at A.D. 1270, then these changes occurred several years after that date. I propose that the two kivas functioned as pairs that mirror the metaphor of the two warrior twins: the voice of *Pöqánghoya*, the one who "keep[s] the world in order" and *Palöngawhoya*,"the echo," (Waters 1977:4-5) come to mind here.[103] This is a theme that repeats throughout the mythic and ethnographic literature. Using this analogy, the later and less elaborate west kiva serves to echo the activities in the more elaborate older kiva to the east. Access between this room and the room directly to the north (structure 1512), as with all the bi-wall rooms, was blocked at some point signaling a change in use of the room through limiting entry. I estimate the content of these samples reflect such changing behaviours. The refuse consisted of a thick layer of ash and charcoal that was disturbed by rodent burrowing. I compared two samples collected from secondary refuse encountered on an exposed floor. Both samples were collected from the same segment and stratum, below modern ground surface, wall fall, fill and additional wall fall.

[103] In his recounting of consultants' narratives, Courlander (1971:237) tells of *Pokanghoya*, the elder of the young warrior gods, and *Polongahoya*, the younger, and an epic battle with the Navajo at Orayvi. Outnumbered by repeated Navajo attacks the warrior brothers stepped in and the Navajos fled. "The Navajos did not come back to Oraibi [sic] because of their experience with the warrior gods" (190). The durability of the warrior brothers persists in legend and in this case, in precontact history on the Hopi mesas.

The samples came from the roof of the building or a second storey, if indeed there was a second storey. The refuse consisted of a thick deposit of ash, charcoal and a few artifacts in an orange brown silt loam (CCAC 2004: rooms, structure 1511, PD data). There was extensive rodent burrowing in this stratum. As it is, based on the strata and surfaces (above sterile three strata of construction refuse and a prepared floor and roof fall), it is plausible that the samples captured transitional use of the building when presumably the occupants were discarding remains for purposes other than the original intent of the room. Detail of the D-shaped building and the room is synthesized in chapter seven (p. 228). All data collected for these samples are presented in Table E.19 (Appendix E).

New flotation sample FV19 (PD 1259, FS 35) measured 1000 ml before processing and yielded 163 ml of light fraction. I examined 125.1 ml subsampling the .71 and .2 mm portions due to abundance of sediment in the two finest screens and examined the 1.4 mm in its entirety. FV19 is compared with a previously analyzed one-litre volume (PD 1259, FS 40) referred to here as CV19/"volume 1." This sample measured 1000 ml pre-flotation and yielded 44 ml of light fraction, 42 ml was examined.

Original findings: CV19

CV1 produced a small amount of *Juniperus* charcoal and a single shrubby fuelwood identified as *Purshia* charcoal. A *Cucurbita* and a cheno-am seed provide the only evidence of food resources in this sample. Very little evidence of disturbance in the form of insect pellets or other debris is noted.

New findings: FV19

This sample contained *Juniperus*, *Amelanchier/Peraphyllum*, *Cercocarpus*, *Populus/Salix* and *Prunus/Rosa*-type charcoal. Similar to sample FV16 from the plaza area at the entry to the west kiva and bi-wall rooms, I identified a needle and thread grass (*Stipa/Hesperostipa comata*) awn fragment. Some worked yucca fibers (*Yucca*/*Yucca baccata*-type) are noted.

Four genera were recovered in the original sample compared to eight genera/species identified in FV19, six are new for this deposit. The materials from the additional sample enhance the interpretive potential of the deposit, specifically increasing the variety of fuel wood types. For this comparison, an additional volume provides new plants and potentially 15 new inference values. As an accumulation associated with the later occupation of the D-shaped building, the materials present here suggest that a variety of trees, shrubs, wild plant seeds and squash were used or discarded in this room. The presence of a gourd/squash and cheno-am seed in the original sample may represent only a fraction of the food remains that were originally deposited into the room if the presence of a rodent(s) contributed to the loss of edible remains (Table 8.21).

Table 8.21 Suggested inference potential: secondary refuse comparison 5 (charred remains).

Interpretive Category	Volume 1 (CV19)	New volume (FV19)	New taxa[a]
Foods			
Domesticates (FD)	*Cucurbita*	-	-
Wild resources, weedy (FW)	Cheno-am	-	-
	-	*Stipa/Hesperostipa comata* [?][b]	*Stipa/Hesperostipa comata* [?][b]
Wild resources, nonweedy (FN)	-		
Wild resources, other (FO)	-	-	-
		-	-
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	-	*Pinus edulis*	*Pinus edulis*
	-	*Pinus*	
Shrubby growth habit (FLS)	*Purshia*	-	-
	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
	-	*Cercocarpus*	*Cercocarpus*
	-	*Populus/Salix*	*Populus/Salix*
	-	*Prunus/Rosa*	*Prunus/Rosa*
Tinder types (FLT)	-	*Pinus*	*Pinus*
		Amelanchier/Peraphyllum	*Amelanchier/Peraphyllum*
Other			
Other, ecological (OE) [seasonality]	*Cheno-am* [summer]	*Stipa/Hesperostipa comata* [spring]	*Stipa/Hesperostipa comata* [spring]
Other, unknown (OU)	-	Monocotyledon	Monocotyledon
	-	Poaceae	Poaceae
	-	*Stipa/Hesperostipa comata* [?][b]	*Stipa/Hesperostipa comata* [?][b]
Other, worked (OW)	-	Unknown fibers	Unknown fibers
Genera/species count	**4**	**8**	**7**
Inferred interpretative value	**5**	**15**	**15**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.
[b] [?] food use presumed, not supported by historical records which documents only ritual use.

Similar to sample FV16 from the plaza outside the west kiva (the latest and less elaborate kiva 1502), unusual evidence of *Stipa/Hesperostipa comata* was identified in the new sample. In the context of the D-shaped building, the presence of an unusual grass type suggests something different than typical residential activities occurred in this building. The connection to Hopi men's *Wuwuchim* initiation ceremony is interesting in this location (Courland 1971:239; Parsons 1996 [1939]:497)(see also pp. 310-317 this chapter for plaza 1500 refuse). These specimens are likely to be subject to subsampled due to size. An additional flotation sample was collected from this deposit and is unprocessed and archived for future analysis.

Secondary refuse comparison 6: west bi-wall room 1513, D-shaped building

Two samples are compared for this room located on the western half of the bi-wall in the D-shaped building. Room 1513 is notable for evidence of red and white plaster, green pigment and almost complete canid skeleton (chapter seven, pp. 226-227). Its location on the northernmost curve of the bi-wall rooms more closely oriented to the less elaborate and later kiva suggests the room may have served at a passageway into the more elaborated space of the east kiva if movement through the peripheral rooms was designed to draw people into a elaborated and cosmological space as proposed by Ortman and Bradley (2002). Both samples were excavated from one stratum above the original bedrock surface located below layers of roof and wall fall debris. An apparent firepit feature was located in the roof fall stratum of this room thought to be a hearth that collapsed through the roof or from a possible second storey (CCAC 2004: rooms, structure 1513). The room apparently ceased being used before the abandonment of the block (occurring sometime after A.D. 1270) based on the deposition of refuse and the blocking of doorways that previously allowed access to other bi-wall rooms. I assign a late occupation context for the refuse here capturing transitions in behaviour that are clearly seen in the twin kivas and in the great kiva late in the occupation. In the case of the D-shaped building, this would have been after the less elaborate west kiva was built and re-plastered and resurfaced several times. The accumulation is described as a small amount of trash located on the floor. Only a portion of the floor was exposed. Investigators noted “large amounts of green pigment,” artifacts, burned and unburned plant remains, animal bones and burned adobe (CCAC 2004: Rooms, Structure 1513) in association with the samples examined here. Abandonment of room 1513 is interpreted to have occurred while occupation of Block 1500 continued (CCAC 2004 Rooms). The best estimate for the dates of the accumulation is late in the occupation of the block that I estimate reflects a transition to new activities (circa earlier years of the A.D. 1270s).

New flotation sample FV20 (PD 1208, FS 7) was originally 1000 ml and yielded 396 ml of light fraction. I examined 265.9 ml including all 1.4 mm screen for the same reasons I did with all D-shaped building samples, the particle size is not difficult to manage and assess and the context of deposition too compelling. I subsampled the .71 and .25 mm portions because of excessive retained sediment. The results of analysis are compared with previously analyzed 1000 ml flotation sample (PD 1208, FS 16), now documented as CV20/“volume 1.” This sample was collected from the same segment and stratum and yielded 45 ml of light fraction of which 39 ml was examined. The distribution of the fraction by screen size is unavailable. All data are recorded in Table E.20, Appendix E.

Original findings: CV20

One piece of *Juniperus* charcoal and many *Prunus/Rosa* charcoal fragments were identified which are interpreted as fuel wood or tinder.

New Findings: FV20

I identified charcoal of *Juniperus* and *Pinus edulis*, and shrubby genera and species that include *Amelanchier/Peraphyllum*, *Artemisia tridentata*, *Cercocarpus*, *Ephedra* and *Prunus/Rosa*. There is more variety of "tinder type" materials in FV20: *Juniperus osteosperma* leaves, twigs, *Juniperus* bark, *Pinus ponderosa* needles (Ponderosa pine)(photograph D.17, Appendix D), *Amelanchier utahensis* (Utah serviceberry) buds (photographs D.62-D.73, Appendix D) and twigs, and Poaceae (grass) stem fragments (Poaceae stem type A [photographs D.36 and D.37, Appendix D]). FV20 also contained a variety of domesticates including *Cucurbita moschata* (butternut squash)(crushed seeds), *Cucurbita*-type and *Lagenaria* (bottlegourd)(rind) and *Zea mays* (cob fragment). Wild plants include *Portulaca retusa* (seed) and *Ephedra* (in the form of stems/twigs) and *Yucca baccata* (datil yucca) stalks, leaves and twisted fibers (the stripped fibrovascular bundles of yucca leaves). There was a quantity of unknown botanical remains. Bark, buds, cones, epidermis fragments, flowering heads, seeds, and tissues suggest a number of different processing activities are represented in this sample. The presence of uncharred remains of domesticates indicates excellent preservation conditions. Non-botanical material includes charred insect remains (including termite pellets) and adobe fragments.

The new sample provides considerable new evidence of plant use for this deposit; evidence that is almost completely absent in the first sample analyzed demonstrating the problem of sample selection for the most productive samples when it comes to microscopic remains. Volume 1 produced two genera (and two associated inferences). With the additional sample, an array of different activities occurred that involved the use and discard of domesticate and wild resources some uncommon for SCP. I account for twenty genera and species and twenty-eight inference values of use and ecology. Based on the captured richness of volume 1, the deposit could have been interpreted to reflect declining resources and suggest little use or discard of plants occurred in this room. This assessment is not supported when the material recovered in second sample is considered. The fuel wood choices are also interesting in FV20. The predominance of *Ephedra* (17 specimens of charcoal and 19 specimens of stems/twigs) hints at special activities associated with the use of ephedra as I have previously described. A quantity of stems with developing cones (photographs D.12-D.14, Appendix D) not only affirms the use of this plant type, but also confirms a season of use. Evidence of termites tells us that old termite infested wood was burned or an active termite infestation was present. Unusual remains warrant further speculation. Table 8.22 (over) provides a breakdown of potential inference values for these samples.

Table 8.22 Suggested inference potential: secondary refuse comparison 6 (charred remains).

Interpretive Category	**Volume 1 (CV20)**	**New volume (FV20)**	**New taxa[a]**
Foods			
Domesticates (FD)	-	*Cucurbita moschata*	*Cucurbita moschata*
	-	*Cucurbita* sp.	*Cucurbita* sp.
Wild resources, weedy (FW)	-	*Portulaca retusa*	*Portulaca retusa*
Wild resources, nonweedy (FN)	-	-	-
Wild Resources, other (FO)	-	*Ephedra*	*Ephedra*
Fuels			
Non-shrubby growth habit (FLN)	*Juniperus*	*Juniperus*	-
	-	*Pinus edulis*	*Pinus edulis*
Shrubby growth habit (FLS)	*Prunus/Rosa*	*Prunus/Rosa*	-
	-	*Amelanchier/Peraphyllum*	*Amelanchier/Peraphyllum*
	-	*Artemisia tridentata*	*Artemisia tridentata*
	-	*Cercocarpus*	*Cercocarpus*
		Ephedra	*Ephedra*
Zea mays cob remains (FLZ)	-	*Zea mays*	*Zea mays*
Tinder types (FLT)	-	*Juniperus osteosperma*	*Juniperus osteosperma*
	-	*Juniperus*	-
	-	*Pinus*	-
	-	*Pinus ponderosa*	*Pinus ponderosa*
	-	*Amelanchier utahensis*	*Amelanchier utahensis*
		Cercocarpus	*Cercocarpus*
Other			
Other, ecological (OE)	-	*A. utahensis* [spring]	*A. utahensis* [spring]
[seasonality]	-	*Ephedra* [spring/summer]	*Ephedra* [spring/summer]
	-	*Portulaca retusa* [summer]	*Portulaca retusa* [summer]
		Termite (uncharred)	Termite (uncharred)
Other, unknown (OU)	-	*Amelanchier utahensis*	*Amelanchier utahensis*
	-	*Lagenaria*	*Lagenaria*
	-	Monocotyledon unknown	Monocotyledon?
	-	Poaceae (type A)	Poaceae (type A)
	-	*Yucca baccata*	*Yucca baccata*
Other, worked (OW)	-	*Yucca*	*Yucca*
Genera/species count	**2**	**20**	**17**
Inferred interpretative value	**2**	**28**	**24**

Notes:
[a] Number of taxa based on interpretive categories contributed by the additional sample.

Revisiting pine: *Ponderosa*. Several charred Ponderosa pine needle fragments may be associated with unidentified pine charcoal in samples may be *P. ponderosa*. Ethnographic sources indicate that ponderosa pine was the wood of choice for ladders and roof beams. The needles are documented as used in "Cloud tobacco" (Whiting 1939:40). Underhill (1991[1946]) documents the leaves of *Abies concolor* (balsam fir), *Mentzelia multiflora* (many flowered mentzelia), *Nicotiana attenuata* (coyote tobacco), *Onosmodium thapsus* (borage/marbleseed), *Pinus ponderosa*, *Portulaca oleraceae* (common purslane) and *Verbascum thapsus* (common mullein) as tobacco. (Purslane and common mullein are smoked together in curing). Whiting (1939:40) documents additional information on the use of tobacco from Stephen's journal (1936:599):

> "Cloud tobacco" is a mixture of native tobacco and the "young leaves of spruce, pine and aspen. Once in four years each kiva sends out three or four of the most trusted young men to gather the desired young leaves; only those growing on the very tip of the tree are gathered...carefully dried and stored in a bag, and...only used for ceremonial smoking in the kiva."

Other species include *Gossypium hopi* (cotton), *Phragmites communis* (reed), *Populus aurea* (aspen), *Pseudotsuga mucronata* (Douglas fir/"spruce"), *Nicotiana trigonophylla* (desert tobacco) and *Zea mays.* As a tobacco medicine, Whiting records *Salvia carnosa* (sage) and common mullein (1939:40). Like *Amelanchier, Artemisia, Cleome, Lagenaria, Phragmites, Populus* spp. (cottonwood), *Salix* spp. (willow), *Sporobolus giganeus* (dropseed)(and a few others), *Pinus ponderosa* is used in the manufacture of prayer-sticks or "prayer feathers" (Parsons 1996 [1939]:8). Prayer-sticks are decorated with the feathers of raptors and small birds.) *Pinus ponderosa* is recorded as an element in rituals associated with rain. Ponderosa pine needles are attached to *pahos* "to bring the cold" (Stephen 1939:78). Bunzel (1932:486, 487; italics added, Zuni) notes:

> Clouds and rain are the attributes of all the supernaturals, especially the *Uwanami* [rain-makers] and the katcinas. Wind and snow are associated with the War Gods [wind and snow are the domain of the Bear and Sandhill Crane clan – jvr]. Windstorms during ceremonies are due to incontinence or other malfeasance on the part of the participants or to sorcery on the part of some jealous or envious outsider. The whirlwind appears in folklore, but not in ritual. All natural phenomena are personalized, and tales are told of them. But they are not therefore necessarily *a:wona;wiʔlona* ["the ones who hold our roads" or "impersonal forces that influence human affairs such as the sun, the earth, the corn, prey animals, and the gods of war," and their help is "secured by offerings, prayers and magical practices"].

Parsons (1996 [1939]:18) states, "all spirits or sacrosanct persons [*a:wona;wiʔlona*] have a road of corn meal or pollen sprinkled for them when their presence is requested." The rain societies of Zuni and Hopi War chiefs are associated with medicine for lung diseases (Parsons 1996 [1939]:116). *Pekwin*, the "zenith among the high Rain chiefs" of Zuni is the Sun-watcher, the keeper of the calendar, announces solstice ceremonies from the roof and "makes the road of the kachina [sic] chiefs." Most revered of all Zuni, the *Pekwin* installs new Rain chiefs and War chiefs (123), the Elder Brother Bow chief and Younger Brother (125), the earthly representatives of the mythic War Twins. The war chief at Taos Pueblo in northern New Mexico is the Bear People society (125).

<u>Utah serviceberry: *Amelanchier* sp</u>. The Hopi are recorded as using serviceberry wood (*Amelanchier pallida* or shadblow or *tuwaʔvi* for prayer-sticks, bows and arrows and lightning frames (Whiting 1939:41,79). Similar to this deposit, a quantity of Utah serviceberry buds were also identified in FV14 (midden 1214), remains that to date, have not been identified elsewhere at SCP. It has been identified in flotation and vegetal samples from the Hedley Site Complex and Wood's

Canyon Pueblo (CCAC 2015a). Although the quantity of specimens is low in FV20, it is an example of recovered plant material that suggests more than fuel or tinder material. The presence of buds situates use as a late spring early summer season activity. As a "rare" or previously unaccounted for species (and part), Utah serviceberry buds in the context of a building with unique features lends weight to broader interpretations than food or fuel uses.

Maize: revisiting "absence." The absence of maize reproductive parts based on the analysis of the two samples is, as has been the case throughout this analysis, an interesting absence. This may be due to disturbance, a pre-harvest deposition (the presence of squash and gourd remains suggest otherwise), a change in use of the room to one where maize is not used, or the use of the D-shaped building in this room at least as a space of preparation for ritual rather than a preparation of cuisine. The use of finely ground corn meal as integral to historic ceremony may be obscured because ground maize is used. It is consistent with the historic record to suggest that activities in this building are associated with mitigation strategies to ensure the maize harvest later in the year. The Hopi and Zuni record of seasonal ceremonies do not directly respond to "famine" but rather are part of a normal ceremonial cycle. The remains of Utah serviceberry and ephedra parts (both late spring early summer availability) suggest intriguing links to spring/summer ceremonial activity. Although a single maize cob fragment was recovered and interpreted here to represent evidence of the burning of cobs, in light of the abundance of other domesticates, it is an interesting lack of edible maize, possibly because it was processed elsewhere. There is no obvious mealing room in the D-shaped building. The cooking or processing of squash seeds, both butternut (*Cucurbita moschata*) and possibly pumpkin (*Cucurbita* sp./possibly *pepo*), or accidents in the cooking of these species may be associated with stored seeds used for cooking oil. The use of crushed squash seeds to oil *piki* stones is documented by Cushing (1920) in the making of *piki* bread. Squash species can be distinguished by the presence or absence of "fringes" on the margins of their seeds (see Appendix C for identification criteria, photographs D.4-D.6, Appendix D). The seeds recovered are broken and fragmented. As I have already noted, Cushing (1920:305, 332) documents the Zuni use of squash seeds for food, medicine and ceremonial purposes. Other Pueblo groups share similar historic uses. The presence of smashed squash seeds supports an interpretation of maize flour in the *absence* of corn remains in this respect. The allusion to the *a:wona;wiʔlona* and the corn meal road suggests that in ritual contexts the presence of non-milled maize should not be expected but the use of maize in milled form more appropriate. The presence of stones in hearths, as the "hot stones" required for wafer bread as opposed to grinding stones for milling, may offer additional support for inferences of bread making. Stephenson (1915:62) records the Zuni use of ground squash seeds as part of a healing "recipe," although the medicine includes maize and native seeds not recovered here.

Other domesticates. Rainey and Adams (2004) note that the Hopi dried and stored the meat of gourd and squash for winter use. Rind fragments from gourd (*Lagenaria*), both charred and uncharred were observed in the additional sample. These remains were also found in room 1205 and the D-shaped building in deposits that accumulated late (or “latest”) in the occupation.

Wild seeds. Wild seed evidence consists of a single specimen of *Portulaca retusa*. The minuteness of the seed dictates that it will sort into the smallest and most time consuming light fraction screen, the .25 mm. Subsampling imposed in at this particle size probably contributes to less visibility of the plant in archaeological deposits. The edible stems and leaves were traditionally used for greens. The seeds in the context of special buildings may hint at the use of tobacco (“Cloud tobacco”). The importance of this “caterpillar corn” (Fewkes 1896:15; footnote 87, p. 255, this chapter) suggests that the seeds, as minute as they are, were recognized, described with accurate detail and linguistically marked in association with maize. Little is written about purslane to identify why it was an ingredient in Cloud tobacco. Recent animal trials have identified *Portulaca oleracea* having beneficial pharmacological effects (Ross 1999:255-261). Known as an ethnomedicine around the world, the plant is ingested as an antiseptic, to reduce fever, and treat internal parasites. It has a long history of use in traditional Chinese Medicine “to remove toxins” (Zhou et al. 2015:1). In the context of the D-shaped building the seeds of purslane like other species noted here and, not commonly found elsewhere, may have cultural meaning associated with curing and ceremony. Subsampling is assured to limit representation of purslane.

The additional sample enhances the interpretive value of the deposit for speculating on uses of the D-shaped building. Domesticated food resources were clearly available and discarded here. Using ethnographic records, the plants I identified in FV20 hints at ceremony or ritual use occurring during a phase that is distinguished by transitions and shifts in behaviour that we might be tempted to associate with drought and resource decline. Van West and Dean (2000:23-24) suggest that the Great Drought at Mesa Verde was underway by A.D. 1273 and if this is the case, presumably ceremonial mitigation should be expected to continue, or expand in scope. If enough people had already left Sand Canyon this may also have diminished numbers of people available to perform and participate in ceremony changing the scale of events. Adams et al. (2007: para. 55) interpret the D-shaped building and great kiva as ritual spaces. The plant assemblage captured in FV20 supports this assessment. Combined with unusual faunal remains and an architectural signature that suggests spiritual themes, it is evident that social organization of the kind recorded in both historic and contemporary ethnographies may well have played a role in the use of the D-shaped building. The limiting of flotation sample analysis for this deposit underestimates interpretative potential to highlight ceremonial activities in what is a strikingly unusual structure. Another flotation sample (no volume amount recorded) for this deposit is unprocessed and archived should additional analysis be desired. No faunal remains are documented for this deposit.

Secondary refuse summary (Table F. 5, Appendix F)

In all, twenty-three secondary refuse (secondary refuse and midden) deposits were evaluated in this analysis of bulk volume to assess sample adequacy and interpretative value of the material recovered for trash accumulations. Some of the samples were excavated from public spaces: the great kiva, the courtyards in block 1000 and 1500 and the D-shaped bi-walled building rooms. Additional samples yielded genera and species that support an interpretation of little evidence to suggest obvious resource stress as proposed by Adams and Bowyer (2002). The apparent increase in the use of wild species has alternative explanations, most notably inferences of curative effects. One sample (FV20) provides the highest diversity and richness associated with the trash accumulation in the D-shaped building (room 1513). Multiple lines of evidence develop a picture of this room or others nearby as locations of specialized activities with plants, perhaps indicative of normal ceremonial practice as seen in the historic record. As "trash," the recovered evidence also exposes a lack of concern for the discard of edible remains that requires some consideration in any assessment of famine or resource stress. Although there are common trends in the data, all samples in this analysis were subsampled using the SAC approach and I suspect the wild plant record is biased as demonstrated in simulation.

Secondary refuse deposits do not typically provide good last-season-of-use evidence because of unclear depositional sequences. As the plant record of SCP shows, plants were harvested from spring to late fall and were used for a variety of purposes, discarded in what may or may not be a haphazard way. Not unexpectedly, secondary refuse deposits require more than a single flotation sample for interpretative purposes. For this reason, inference values are worth revisiting as a method of exploring deposit-specific activities in archaeological sites. The analysis of samples I have presented here attempt to view sample content as "recipes" in context, some of which are situated in spaces that at one time were different and special as an attempt at a local theory of ethnobotanical evidence. A broader interpretation of these plant combinations may prove to suggest more complex analysis of individual deposits. The data collected for all secondary refuse samples evaluated here are documented in Table F.5, Appendix F.

Chapter summary

Additional samples provide valuable new cultural and ecological information about individual deposits contributing to a more enhanced understanding of the Sand Canyon Pueblo site occupation. I have interpreted sampling effectiveness from the perspective of local theory (Whiteley 1998) where the ethnobotanical and ethnographic data are situated in a continuity of practice from ancestral times.

Accounting for species or genera numbers is useful to calculate a measure of the extent that limited sampling has on recovery—a type of database approach. Enhanced interpretation is gleaned through speculation of the minute details of the "community" from which the remains were collected. Using an interpretative value approach and in-depth analysis of the site, the context and the content shifts the analysis to an anthropological ethnobotany where the devil is in the details. Sampling decisions and assessment of adequacy using an interpretative approach can be tailored to specific research questions in a more responsive way. The process reveals that the goal of sampling to redundancy, limiting sampling, and plotting curves, whether at the sample or subsample scale, reflects a fundamental truth. The greater you sample, the more species you will find (Arrhenius 1921; Rosenzweig 1995). The flotation samples (FV samples) used here were subsampled using the SAC approach, the next chapter will detail how the approach operates on previously unexamined residua.

Chapter 9 Sand Canyon Pueblo sample study, part 2: species-area curve subsampling

Chapter overview

Uncharred microscopic debris and sediments make up the bulk of residues in most flotation samples. The species-area curve subsampling approach (SAC) was designed to manage this content by limiting sampling effort while aiming to capture adequately representative subsets of botanical remains through limited analysis of the smallest particle sized light fraction remains. In this chapter I document data collected from previously subsampled light fraction from Sand Canyon Pueblo (SCP) flotation samples to assess how well the approach achieves these ends.Appendix G and Appendix H provides summary tables of the original and new data for each sample. New observations are plotted on accumulation curves to explore patterning and presented in Appendix H, which also includes tabulated data on unknown botanicals and nonbotanical remains.

Background

The species-area curve subsampling approach (SAC) is applied to the three smallest particle-sized light fraction recovered through flotation processing: the 1.4 mm, .71 and .25 mm particle sizes sorted into geologic screens. Experimental samples demonstrate that the approach significantly underestimates botanical content using simulated samples (chapter four). Small and minute wild seeds are typically recovered in the smallest screens where subsampling could impose an assessment of "rarity" for these important cultural species, the edible seeds that contributed a significant part of the historic and ancient diet (Fry and Hall 1975; Hall 1979; Minnis 1989; Sutton and Reinhard 1995). For this part of the Sand Canyon Pueblo sample study, I assess the effects at the .71 mm and .25 mm particle size, the most problematic in terms of analysis and effort through an evaluation of previously unexamined light fraction. Original analyses of these samples are from data collected by Adams (1989a, 1989b), recorded and synthesized in Adams et al. (2007), and evaluated in Adams and Bowyer (1998).[104] Access to all data can be found in Crow Canyon Archaeological Center (CCAC) databases (CCAC 2004, 2015a). The basic question I pose is:

> *Does the species-area curve subsampling approach effectively estimate redundancy of sampling effort for Sand Canyon Pueblo samples?*

[104] Original data can be found on the CCAC Sand Canyon Pueblo Database (CCAC 2004) and the Multi-site Research Database (CCAC 2015a). Tables for each sample are presented in Appendix G and Appendix H.

In effect, does SAC subsampling estimate botanical "asymptote" or maximum species richness in these portions and does the flexible minimal volume respond to the diversity of the sample in Sand Canyon Pueblo archaeobotanical samples?

The SAC approach limits subsampling in a way that capitalizes on a pattern of species accumulation commonly observed in ecological data, the sharply rising line on a graph or scatterplot that indicates, and/or purports to reflect, the collection of common species gradually tapering off as new species are less and less observed (accounting for rare species). Whether this accumulation method is effective for archaeology and archaeobotany depends on the effects of fundamental assumptions associated with the method. These include the assumptions of an archaeobotanical "asymptote" for light fraction screens. Tied to asymptote is redundancy of sampling effort where further observations yield no new species as more volume is analyzed. We presume that non-occurrence (non-observation of new species) is in some ways related to commonness or rarity of specimens and minimal subsample volumes respond to the diversity of the sample. The SAC approach is fundamentally founded on an accounting of "diversity" that through sampling is identified as an estimated "point of adequate non-capture" of new taxa—the application of the flexible minimal volume. The approach also assumes that sampling to redundancy is:

1) Possible, and that redundancy is a possible sampling reality;
2) That "volume" aka "area" is a key factor in achieving this redundancy; and,
3) Low or high "diversity" defined here as the number of unique genera/species/parts within a sample will be signaled by the non-capture of new genera/species/parts over a certain number of subsamples "minimal volume."

The question in response to these expectations become, *does the content (low or high diversity) impose an accumulation pattern*? I have addressed these questions for SCP samples by plotting accumulations of "diversity" of the smallest screen portions to examine the patterning of observations (Appendix H).

The idea of redundancy of sampling effort in archaeology assumes that we have captured a reasonable assessment of evidence based on the research questions asked. The impracticality of full analysis compels us to make choices about what to count. The possibility that we can identify a point where we are not observing anything new is of obvious benefit. "Redundancy" is appealing and cost-effective. As the experimental study indicates, there are problems with sampling and presumptions of redundancy. There are also several problems with the common/rare patterning assumption. We are in fact, interested in "rare." Rare in archaeology is the key to understanding the cultural realities and the nuances of the past. For the most part, we have the "common" well described: corn-beans-squash-wild plants. Rare tells us about "new," new conditions, new people and new behaviour, or conversely, what was always there but was missed. If the expected accumulation pattern of sample analysis reflects the capture of common and rare species as we are led to believe, the SAC approach will also capture rare taxa. Therefore accumulation curves are useful as visual presentations of “rare” patterns. Curves also demonstrate sampling effects.

Scope of analysis

I use previously analyzed SCP flotation samples to explore the patterning and effects of the SAC approach. Two issues affect the analysis: as a sampling to redundancy application where non-accumulation of new charred genera/species/parts provides a stopping point, and the assessment of new species is dependent on the original processed distribution of the remains. Revisiting a sample after previous analysis and archiving distorts the original pattern. Therefore, I suggest only that the SAC approach was successful or was not successful in accounting for a reasonable estimate of the full complement of taxa. The value of new taxa resides in whether additional sampling yields enough new information to justify the costs of what is a time and effort-intensive process. As with the flotation volume analysis presented in chapter eight, cultural and ecological inferences may provide the value required to justify additional subsampling. The order of observation is illustrated on accumulation curves as a useful way of presenting the data visually to look at patterning, not to reinforce a species-area curve calculation. As previously described, the smallest particle sizes of light fraction are problematic for numerous reasons, not least because they capture fragments. Often these are unidentifiable to genera or species but identifiable as morphologically distinctive comparing well to a known plant or plant part but without sufficient characteristics to support a confident identification. These fragments reflect an “almost genera” conundrum. Fragments that have distinct morphological characteristics can suggest processing or some human action and do not necessarily only reflect distorting mechanisms of deposition, excavation and processing in the lab. Fragments, like the assessment of “rare” are ultimately meaningful. The differences between fragment distributions across samples provide an opportunity to explore human actions in specific deposits. For this reason, I’ve made every effort to document describable remains.

Methods and materials

I selected ten (N = 10) previously examined samples that had been subsampled using the SAC method and had unexamined residua from the .71 and .25 mm light fraction portions. These samples fell within the range of the standardized 1 litre excavation volume. Five (n = 5) of the samples were collected from primary refuse contexts (two firepits and three hearths). Five (n = 5) samples were collected from secondary refuse contexts (four middens and one secondary refuse/generalized trash deposit). The selection of samples for this analysis was constrained for the same reasons as the bulk volume analysis—the lack of comparable samples and lack of comparable samples with unexamined residua. Due to the scarcity of unexamined residua in the 1.40 mm portions, I made no attempt to assess this particle size. Details of depositional and cultural context are outlined in chapters six and seven. Identification criteria are reported in Appendix C. Specimen photographs can be found in Appendix D. Some of the samples evaluated here came from deposits that were also assessed in chapter eight and additional detail about cultural content is included in discussion. All data are reported by individual sample in Appendix G with curves plotted in Appendix H.

Reporting

I use the term "diversity" here to simply account for a variety unique remains, encompassing botanical and nonbotanical/other-types. Abundance of individual species is not the focus of the analysis although counts included in data tables may indicate relative abundance. Each sample has curves that incorporate taxa, botanical and nonbotanical remains based on categories I have identified (Appendix H). These curves plot various types of information outlined in Table 9.1.

Table 9.1 Species-area curve (SC) samples: identification categories for this study.

Category of remains	**Description**
Taxa	• charred botanical specimens, complete or fragmentary that are confidently identified to family, genus or species. • charred and identified botanical "parts" that even when already accounted for by family, genus or species, contribute additional information about human use thus enhancing the interpretative potential of the sample based on categories of food, fuel (fuel types) and other plausible inference value.
Botanical	• charred botanical specimens, complete or fragmentary that are not confidently identified to genus or species by me but have to potential to be so in the future. • uncharred botanical specimens that reflect modern or ancient use that have the potential to enhance interpretation potential. • included as a category to explore the inference potential of fragments.
Nonbotanical/other	• charred or uncharred nonbotanical materials whether identified, potentially identifiable that may suggest a degree of ancient or modern activity. • Charred or uncharred materials that may be botanical but are too degraded or fragmented to identify as such with confidence.

Each curve provides a visual representation of the order of my observations and the describable uniqueness of the screen contents. The term "taxa" refers to the identification of genus/species and part and represents plants or plant parts that have not been previously identified. Following Adams 2004: para.28), "a single taxon represented by more than one plant part may be handled slightly differently…depending on the parts present and types of prehistoric uses they are believed to represent." Wood and seeds of the same genus or species are considered as separate entities based on their interpretative value (for example wood and seeds reflect different uses). Taxa-level materials are charred, presumed ancient and plotted on species accumulation curves (presented in Appendix H) as a solid line. Botanical occurrences are charred, morphologically distinct botanical remains that are currently unidentified to genus or species. Although unique botanical remains may represent a single species they may be present as a result of a processing activity and are considered important fragments or parts for this reason. They are cumulatively plotted as a dashed line. Nonbotanical/other-type occurrences consist of nonbotanical or other unknown specimens and include charred and uncharred unidentified but distinctive botanical or other remains such as insect parts. These are plotted as a dotted line.

I examined the portions one time only and I assume the distribution of taxa or other occurrences is altered from the original analysis and would change again if the samples were re-evaluated a second time due to sorting and storage effects. The results from the original analyses were not consulted until I scanned all ten samples. Botanical richness for each portion is calculated for all SC samples by combining the number of new taxa identified in the previous analysis added to the number of new taxa identified in this analysis.

Practical considerations

For some samples, it is unclear when in the subsampling process new taxa were encountered in the original analysis. When this was the case, the remains were re-screened to identify the screen size in which the taxa were likely found. The sediments labeled "examined" were re-measured to record the volume required. The original data collected are assigned a subsample number based on these calculations. To track patterns of accumulation, I documented observations of new taxa by subsample number. Many of the plants identified here are further explored in chapter eleven and some of the information presented there is detailed in footnotes in this chapter.

Results

Primary refuse thermal features

Sample SC1: early courtyard 1000 firepit

Sample SC1 (PD 609, FS3) was collected from an informal and shallow firepit (feature 2) located against the outer wall of room 1003 (structure 1003) in the courtyard of block 1000 and represents an early episode of courtyard use (chapter seven, pp. 210-211). The firepit measured 66 cm in length, 34 cm in width, and 10 cm in depth and was dug into the courtyard surface. It was later cross cut by a posthole. The pit contained ash, charcoal and rocks (CCAC 2004: extramural Surfaces, nonstructure 1000, feature 2). It is situated near an architectural petroglyph of ground and pecked marks and clusters of pecked marks on the stones of the outer wall of room 1003. The presence of petroglyphs indicates that the firepit or the room served a particular purpose, one that may be associated with a specific group, as would be expected in the historic period (Fewkes 1902). Based on the estimated construction sequence for the courtyard, I consider that the sample reflects a phase of increasing architectural elaboration in the A.D. 1260s that included the construction of the D-shaped building bi-wall rooms, east kiva (1501), and the great kiva peripheral rooms. Sample detail includes the following information (Table 9.2):

Table 9.2 SC1 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	Light fraction retained	Light fraction originally examined	No. of subsamples scanned (original data) .71 mm	.25 mm	Original identified sample content
750 ml	30 ml	22 ml	unknown	unknown	*Juniperus* (juniper) charcoal cheno-am seeds *Physalis longifolia* (common groundcherry) seeds Miscellaneous modern material and uncharred cheno-am seeds

As shown above, the taxonomic richness for the sample based on the data previously collected for SC1 is estimated as three taxa. My examination of the previously unexamined .71 mm and .25 mm residua produced an additional seven new taxa. Data are recorded in Appendices G (Table G.1) and H (Table H.1). Accumulation curves are plotted in Figures H.1a and H.1b (Appendix H).

.71 mm portion

The. 71 mm screen portion measured 4.8 ml. No sample envelopes indicating examined portions were present, so subsampling is presumed. I identified five new taxa in the third, fourth and sixth subsamples consisting of *Artemisia tridentata* (big sagebrush) and *Cercocarpus* (mountain mahogany) charcoal, *Juniperus osteosperma* (Utah juniper) scale leaves, *Pinus* (pine) bark scales and an *Artemisia tridentata* achene. Similar to the previous findings, the residua contained a number of charred and uncharred cheno-am seeds, seedcoats, and immature seeds that are likely ancient. Unknown botanical evidence too degraded or fragmentary to support taxa-level identifications consist of morphologically distinctive specimens representing wood and tissues. These include tissue "type 5" I interpret as *Zea mays* kernel epidermis fragments. Buds and other reproductive parts were unidentifiable by me. Nonbotanical/other-type specimens are limited to disseminules, twigs, a gastropod and insect pellets.

.25 mm portion

The presumed previously unexamined residua for this portion initially measured 8.7 ml. I identified two new taxa: *Portulaca retusa* (purslane)(seeds), and a Poaceae panicoid-type (panicoid grass-type)(caryopsis). Unidentified but distinctive botanical remains include tissue "type 5" that compares well to remains in the .71 mm screen (photographs D.126 – D.128, Appendix D). There are dozens of examples of tissue type 5 in this portion although no evidence of whole maize was observed in the sample. Distinctive nonbotanical/other remains accumulate throughout. New taxa are highlighted as they were observed in the Table 9.3.

Table 9.3 Recovery of charred taxa by subsample number, firepit sample SC1 (new taxa shaded).

Subsample	**Taxon**	**Common name**	**Part**	**No. of specimens**
		.71 mm screen		
3	*Cercocarpus*-type	mountain mahogany	charcoal	1
4	*Artemisia tridentata*-type	big sagebrush	charcoal	1
4	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
6	*Artemisia tridentata*-type	big sagebrush	achene	1
6	*Pinus*-type	pine	bark scale	1
		.25 mm screen		
1	Cheno-am	goosefoot/pigweed	seedcoat	1
2	*Artemisia tridentata*-type	big sagebrush	charcoal	>1
3	*Artemisia tridentata*-type	big sagebrush	charcoal	>1
4	Cheno-am	goosefoot/pigweed	seed	1
5	*Artemisia tridentata*-type	big sagebrush	charcoal	>1
6	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
8	*Portulaca retusa*-type	purslane	seed	1
14	*Portulaca retusa*-type	purslane	seed	1
16	Cheno-am	goosefoot/pigweed	seed	1
17	Cheno-am	goosefoot/pigweed	seed	1
19	*Portulaca retusa*-type	purslane	seed	1
20	Cheno-am	goosefoot/pigweed	seedcoat	1
24	Cheno-am	goosefoot/pigweed	seed	1
24	*Portulaca retusa*-type	purslane	seed	1
26	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
27	Cheno-am	goosefoot/pigweed	seedcoat	1
29	Cheno-am	goosefoot/pigweed	seed	1
30	Poaceae panicoid-type	panicoid grass	caryopsis	1
30	*Portulaca retusa*-type	purslane	seed	1
34	Cheno-am	goosefoot/pigweed	seed	1

This early courtyard firepit content was originally underestimated using SAC subsampling. The value of additional subsampling is explored in the following inference potential of new taxa:

Artemisia tridentata achene (.71 mm portion). One deposit, aboveground rectangular kiva 107, was recorded as containing evidence of big sagebrush achenes (a total of 2,035 specimens). Sagebrush achenes are represented in coprolites throughout the region. Dunmire and Tierney (1997:192) suggest that achenes may have contributed a minor role in the diet. The cultural importance of edible plants as medicine subsumed under the general category “diet” in this case fails to account for the pharmacological potential of big sagebrush achenes and parts as a medicinal strategy.

Artemisia tridentata charcoal (.71 mm and .25 mm portions). The fracture pattern of big sagebrush charcoal may explain its apparent “absence” in the larger light fraction screens. The characteristic “flare/flame” pattern of internal pores is distinctive and often identifiable even on the smallest pieces of charcoal on cross-section. The wood also splits easily along the growth rings contributing to fractures. The previous record consisted of twenty-nine specimens of *Artemisia tridentata* charcoal collected through flotation analysis. It is quite possible that the use of big sagebrush as a fuel type is underestimated due to wood that combusts to ash more so than most. The morphology of the bark, however, displays a characteristic lenticular surface structure. An abundance of minute charcoal specimens with lenticular surface were noted for this sample. [105]

Macrofossil (vegetal) sample analyses produced additional evidence of big sagebrush charcoal most often associated with collapsed structures, wall and roof fall (CCAC 2015a). Big sagebrush may have been a roofing material or was used as a fuel source for the burning of kiva roofs in abandonment and post abandonment contexts (Adams et al. 2007). My alternative explanation is Sand Canyon residents collected big sagebrush as did their descendants and dried the brush on roofs for convenient hearth and firepit use. Thermal features yield far fewer specimens presumably because hearths and firepits in structures are likely to be cleaned out after use. Sagebrush in the context of this early occupation firepit sample refutes the idea that shrubs were resorted to only due to inferences of declining fuel wood availability. The smallest screen sizes are not typically assessed for charcoal but, in this sample, provide data regarding species that fragment and burn so well that they leave behind little evidence.

<u>*Cercocarpus* (.71 mm portion)</u>. Thirty-four specimens of *Cercocarpus* charcoal were identified from flotation sample analysis for SCP (CCAC 2015a). A prolific shrub in the canyon and surrounding area today, the apparent absence of mountain mahogany charcoal in comparison to other wood types may be due to its burn patterns although this is far less likely than big sagebrush. The pores of *Cercocarpus* are fine, small and well spaced and ring boundaries are indistinct. As is the case with big sagebrush, the smallest particle portions of light fraction may provide additional information about wood or twigs. The ethnographic record suggests that mountain mahogany (*putci'vi* or *Cercocarpus eximius* [C.K. Schneid.] Rydb.) was a wood of choice for Hopi ceremonial objects, the bark for dying basketry and other materials (Whiting 1939:27-28, 78). This study has contributed to *Cercocarpus* being identified in burned spots as well as hearths and firepits at SCP.

<u>*Juniperus osteosperma* (.71 mm and .25 mm portions)</u>. Usually inferred to represent a tinder material, only a limited number of charred Utah juniper scale leaves and twigs have been recovered at SCP. The pronounced denticulate margins on the leaves are durable with charring and easily

[105] As a medicine, Hopi *hova'kpi* (big sagebrush) is recorded as used in conjunction with boiled juniper branches as a treatment for wounds and skin conditions (Whiting 1939:94). *Hova'kpi* is culturally important enough to be associated with the southwest direction (directional colour: blue or green) and is featured in the *Powamuy* altar (Voth 1901:76; Whiting 1939:94) hinting that the plant may be associated with guarded medicinal and/or ceremonial practice.

identifiable. Prior to this study the record is eleven twigs and seven scale leaves found in flotation and macrofossil samples. With additional samples and more extensive subsampling, scale leaves have been identified in firepit sample excavated from room 1005, twigs identified for room 204, kiva 208, the hearth in kiva 306, room 805 and midden 1214. Scott and Aasen (1985) record juniper twigs in block 100 deposits. Adams et al. (2007: Table 11) note the presence of juniper twigs (not identified specifically Utah juniper) in Kiva 1004. Juniper wood was widely used as a fuel source at Sand Canyon, making up 88 per cent of wood remains in 80 flotation samples (Adams et al. 2007: Table 11), evidence of twigs and leaves considerably less ubiquitous. The very low relative abundance of taphonomically durable charred juniper twigs and scale leaves does not support an interpretation of the use of these materials as typical tinder for fires, the historic record of juniper medicine suggests alternative explanations. Utah juniper leaves were used in a variety of applications as medicine (Whiting 1939:62).[106] The combination of Utah juniper scale leaves and aromatic big sagebrush suggests that both may have been used as a medicinal combination.

Panicoid grass. Previously eleven grass (Poaceae/Gramineae) seeds/caryopses were recorded for SCP, all recovered in flotation samples. With the exception of a single festucoid-type grass, all are unknown and uncategorized grass types (grasses are notoriously challenging to identify). Coprolite evidence from the Four Corners indicates the ingestion of grass seeds such as *Oryzopsis hymenoides* (Indian ricegrass), *Sporobolus* (dropseed grass) and *Panicum* spp. contributed to Ancestral Pueblo diet (Minnis 1989). Sutton and Reinhard's (1995) analysis of coprolite content from Antelope House document grasses as a major component of diet. The ethnographic record confirms that grass seeds were important in Zuni diet in the historic period. Between 1879 and 1884, Cushing (1920:219; "Food of the Ancients") records a meal of grass seed at Zuni, called *suthl'-to-k'ia* (the "richest and most delicious ever known")(245) and another plant with blue leaves and resembling *Chenopodium* known by the Zuni name, *mi´-tä-li-k'o*, and translated to mean "father-in-law of corn" (245). Added to these, *Portulaca*, wild rice (presumably *Oryzopsis hymenoides*) and various grass seeds were ground and made into "a great variety of mushes, breads, and cakes" (Cushing 1920:253-254, "Food

[106] Particularly important when associated with childbirth, juniper leaves and twigs were boiled in a tea and incorporated in all food for 20 days after the birth ([Hopi] Voth 1905a:52 in Whiting 1939:62). Traditional practice also included bathing and washing of clothing in water containing juniper leaves on prescribed days after childbirth (53) and after burial of the dead ([Zuni] Beaglehole 1935:12). Two Hopi clans are named for Utah juniper (Whiting 1939:47) attesting to its metaphorical content. Used as drugs in the treatment of arthritis, pain and swelling, juniper twigs and leaves are recorded as steeped in teas or bound on wounds (Moerman 1998:290-292).

of the Grandfathers).[107] The minute size of grass grains can explain the recovery and identification of few grasses in archaeological deposits, the seeds likely sorting into the smallest particle sizes of light fraction, subsequently subsampled from considerable microscopic sediment content that typically makes up the bulk of the smallest portion sized light fraction.

Portulaca retusa (.25 mm portion). *Portulaca* is ranked in the top nine plants consumed at Antelope House during Pueblo III. Minnis (1989) categorizes purslane as a core dietary staple for this period, found abundantly in agricultural fields and disturbed habitats. The combination of *Portulaca retusa*, *Chenopodium* (goosefoot), and *Physalis longifolia* seeds show "surprisingly similar[ity] in rank order" from Basketmaker III to Pueblo III implying a "*generally* stable dietary regime" (559; emphasis in original). We should expect to find purslane seeds in abundance at Sand Canyon Pueblo, either as evidence of the use of the seed or as secondary evidence of the use of the greens. In the context of the D-shaped building, the seeds could indicate the use of a tobacco substitute. The ethnographic record of "cloud tobacco" suggests that purslane was smoked in ceremonial contexts (Underhill (1991[1946]). The original SCP archaeobotanical collection consisted of only forty-one specimens of purslane, some uncharred compared to the over 1100 charred cheno-am and 157 charred *Physalis* seeds originally recovered. Deposits that contained purslane seeds include latest occupation (ca. late A.D. 1270s and 1277 as well as earliest occupation, ca. A.D. 1250s-1260s (Plaza 1500 below surfaces). Five additional purslane seeds are added to the record from one sample alone. Size, screening, and subsampling effects contribute to an under-representation of purslane. The Basketmaker III through Pueblo III cheno-am-groundcherry-purslane core dietary combination is well represented in this firepit. Although not recorded as "taxa," unidentified botanical remains offer insights of the use of the firepit

Botanical remains, tissue type 5 (.71 mm and .25 mm portions). I observed more than 30 examples of tissue "type 5" fragments in the .71 mm and .25 mm portions of this sample. Cushing's (1920) descriptions of Zuni cornmeal breads and campfire cuisine in addition to ancient coprolite evidence of milled maize confirm that cornmeal and corn flour is a dietary staple throughout Puebloan history. Finely ground corn has been linked to changing maize grinding technology and

[107] Of the known 32 genera and 325 species of native Panicoideae in the United States (Gould and Shaw 1983:118), the ancient coprolite record is likely the best place to focus identification efforts for grasses for flotation samples! Doebley (1984) also records the historic ethnographic use of 27 genera and 52 species of grass, noting that ethnobotanical sources also indicate that grasses were major contributors to diet with Indian ricegrass, dropseed and panic grasses playing an important role for historic populations. *Panicum capillare* L. (witchgrass [Gould 1981 (1951)]), *P. obtusum* H.B.K. (vine mesquite [Gould 1981 (1951)]) are documented for the Hopi, *P. obtusum* is recorded as semi-cultivated. Ground on metates and winnowed, panic grasses may have been harvested while still green to avoid seed loss due to the failure of the glumes to prevent easy dispersal of the seed (Kelly 1977).

increased efficiency in archaeological contexts. Kennard (1979:561) makes the following observations of maize grinding:

> Every Hopi house has a set of three grinding stones, set in a wooden frame. The metates differ in the degree of coarseness. When corn is ground it is first shelled and cracked, and then ground successively on each of the metates until it is as fine as powder. Since almost all Hopi foodstuffs are made of it, plaques piled high with meal are one of the commonest forms of payment in exchanges between households.
>
> The other essential item of equipment is the piki stone, sometimes located in a back room, but more often in a small house built for that purpose. Piki (*piki*) is a wafer-thin bread of finely ground blue cornmeal. A fire is built under the stone, the surface is rubbed with the oil from cotton seeds or watermelon seeds [Robbins et al. (1916) not the use of squash seeds for the same purpose], and a thin batter is spread upon the hot stone by hand. The piki is peeled off the stone, turned over for a minute, and then folded into squares or rolled up like a diploma. It is prepared before all ceremonies, and it is an item of daily consumption.

The dietary significance of ground maize, Kennard's maize "powder," has implications for speculating on the apparent absence of maize remains in some samples. Although it is tempting to presume lack of maize in the absence of firmly identifiable or described parts, the fine processing of maize during non-harvest seasons can be expected. A re-evaluation of metate bins and metate slabs for coarseness of surface could provide secondary evidence of flour. From Chacoan times, grinding technology made use of a three-metate bin (or more) configuration that presumably reflects a three-stage flour making process, not just more ground maize. In the case of single metate slabs, reflecting a less fine ground, perhaps limited to wild seed processing or a combination of corn and wild. If only coarse stones are used in late occupation deposits at SCP, it may be the result of less effort spent grinding corn into finer flour. The "moving metates" that saw the dismantlement of mealing rooms in blocks 800 and 1200 may provide clues as to the dietary and/or ritual priorities of the late A.D. 1270s, a time that may have required less finely processed corn. Conversely, the movement of mealing function to other areas (block 500 retained its mealing room) may be the result of a shifting population, a declining population, a different communal focus or a combination. Blackened stones in thermal features at Sand Canyon Pueblo on further analysis may provide additional support for the use of corn flour in a process that mimics the historical making of *piki* bread. Artifact analysis for the room indicates that a two-handed mano, a technology appropriate to both bin and slab processing, was recovered on the same surface as evidence of "tissue type 5," although these tools are common in a variety of contexts. The non-recognition of potential maize fragments and/or subsampling imposes a "non-maize" deposit in the case of sample SC1 that may be far from accurate. The tower 1008/1019 with its sealed over firepits and rooms 1002 and 1005 with their multiple firepits in close proximity to this firepit is suggestive of the historic practice of using finely ground maize as offerings and to create maize “trails” linking altars and other culturally symbolic areas.

The use of this courtyard firepit is helpful in estimating potential activities of later periods. Presumably these earlier times were ones of abundance associated with an increasing and building population that may have included new immigrants and new traditions if the differing architectural configurations of the various blocks at SCP are any indication. New data collected from SC1 also provides an opportunity to assess the patterning of accumulation of species using the SAC curve approach (see Table G.1, Appendix G; Table H.1, Appendix H). Although the distribution of remains is presumed changed from the original distribution first analyzed, the patterning of observations suggests subsampling and screening effects are similar to those demonstrated in experimental samples. The five new taxa identified by me in SC1 were scattered throughout the .71 mm portion with redundancy achieved in the sixth subsample of a total of seven subsamples. Botanical and nonbotanical/other-type remains that include unknown charcoal, tissue and angiosperm-type pith, uncharred, unique and unknown disseminules, twigs, gastropods and insect fecal pellets were also observed as subsampling proceeded. A staggered pattern of observations is evident and does not reflect one of common remains accumulating rapidly and abundantly in the initial sampling phases.

The most problematic portion is the .25 mm portion that required the analysis of 37 subsamples (.3 ml each). Redundancy/asymptote was achieved by the 30th subsample although distinctive but unique botanical remains and other materials continue to accumulate. In this portion, unknown botanical remains consisted of an unidentified/unidentifiable seed, seedcoat and buds. Nonbotanical remains consist of insect pellets, casings and parts, an unidentified mineral and what appear to be modern fibers. At an average of twelve minutes of analytical time per subsample, approximately eight additional hours was required to account for the two new taxa present in this portion (purslane and panicoid grass). Similar to the experimental results, “asymptote” is achieved when the bulk of sample material is examined, the noncapture of taxa and other botanical remains in the original analysis was an interpretative loss. As a re-used feature (becoming a posthole) it is possible that ancient seed rain from activities in the courtyard later may distort the estimated temporal context of sample deposition as “early.”

<u>Sample SC2: *three-firepit* room 1002 (south corner firepit)</u>

Sample SC2 was recovered from an informally constructed and shallow firepit (feature 1) in the south corner of room 1002 (chapter seven, p. 208-209). It is one of three firepits recorded. The room is important for its temporal association (in the context of A.D. 1277 and the final days of occupation) in a block that shared familial connections within the block and with the residents of block 100

(Kuckelman and Martin 2007). Historic activity noted by Fewkes (1902) for the Warriors' Room at Walpi Pueblo is suggestive of similar activity. The three contemporaneous firepits of room 1002 indicate more than one activity area in the room. The tested firepit here was elliptical in shape and measured 42 cm in length and 36 cm in width (depth is unrecorded) with light grey ash was left *in situ*. The record of the sample is outlined in Table 9.4.

Table 9.4 SC2 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	Light fraction retained	Light fraction originally examined	No. of subsamples scanned (original data) .71 mm	.25 mm	Original identified sample content
unclear, could be 1.2 L.	30 ml	20 ml	unknown	unknown	*Juniperus* charcoal *Amelanchier/Peraphyllum* (serviceberry/peraphyllum) charcoal *Physalis longifolia* (common groundcherry) seeds, uncharred

Taking into account uncharred seeds likely ancient in origin, this sample was originally assessed as having three taxa. I identified six new taxa from the unexamined residua of this sample. Taxonomic content is described further by screen size. Data are recorded in Appendices G (Table G.2) and H (Table H.2). Accumulation curves are plotted in Figures H.2a and H.2b (Appendix H).

.71 mm portion

The previously unexamined residua measured 2.9. I observed four new taxa including one new part in the first, second, third subsamples. These consist of *Artemisia tridentata* charcoal, an *Amaranthus*-type (pigweed/amaranth) seed, a monocotyledon stem and a new Sand Canyon Pueblo taxon/part, a segmented fruit schizocarp with a peltate stalk that compares well to the fruits of modern *Malva parviflora* (cheeseweed mallow), *M. crispa* (cluster mallow), *or M. neglecta* (common mallow), all found in Colorado today. Labeled here as "Sand Canyon *Malva*-type fruit" and described in Appendix C (photographs D.59-D.61, Appendix D), another specimen of the same type was also recovered in sample SC10. Unknown, but morphologically distinct, charred botanical remains include a leaf fragment, charcoal similar in morphology to *Artemisia tridentata* with lenticular surfaces, and unknown tissue (nodulose in surface appearance) described in Appendix C. Nonbotanical/other-type materials include uncharred and unidentified disseminules, uncharred Poaceae florets, cheno-am seeds, an unknown seedcoat, charred bone and scant insect parts and pellets.

.25 mm portion

The previously unexamined residua of the .25 mm portion measured 6.5 ml. Two new taxa, charred cheno-am and *Portulaca retusa* seeds, were observed in the first and twenty-fourth subsamples. This portion consisted of an abundance of charcoal with a lenticular surface pattern (sagebrush?), specimens of tissue "type 5," inferred as *Zea mays* kernel epidermis, and a degraded and unidentifiable seed. Uncharred minute insect casings, parts and fecal pellets were abundant. The presence of fibres, almost all brightly colored, are likely modern in origin (an excavator's sweater?). The patterning of accumulated observations suggests that redundancy/asymptote for this sample, or something close to it, was achieved on analysis of both portions. Tissue type 5, suggests a milled maize such as demonstrated by Sutton and Reinhard (1995). Rather than firepits, hearths are considered the major indoor cooking features, special rooms may have served as activity areas such as we see in the historic period. The close proximity to the tower hints that room 1002 may have served an adjunct function to the tower. In order of observation, new taxa are recorded for both screens in Table 9.5.

Table 9.5 Recovery of charred taxa by subsample number, firepit sample SC2 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
1	*Artemisia tridentata*-type	big sagebrush	charcoal	3
2	*Artemisia tridentata*-type	big sagebrush	charcoal	2
2	*Amaranthus*-type	pigweed	seed	1
3	Monocotyledon-type	monocotyledon	stem	1
3	Sand Canyon *Malva*-type	mallow-type	fruit schizocarp	1
4	*Artemisia tridentata*-type	big sagebrush	charcoal	1
		.25 mm		
1	Cheno-am	goosefoot/pigweed	seed	1
1	Monocotyledon-type	monocotyledon	stem	1
3	Cheno-am	goosefoot/pigweed	seed	1
5	Monocotyledon-type	monocotyledon	stem	1
8	Sand Canyon *Malva*-type	mallow-type	fruit schizocarp	1
10	Monocotyledon-type	monocotyledon	tissue	1
16	Sand Canyon *Malva*-type	mallow-type	fruit schizocarp	1
24	*Portulaca retusa*-type	purslane	seed	1
25	Sand Canyon *Malva*-type	mallow-type	fruit schizocarp	2

Full analysis of the smallest light fraction portions indicates additional plants were processed, stored or discarded in this room. The value of additional subsampling is explored in the following analysis of new taxa:

Amaranthus (.71 mm portion), cheno-am and *Portulaca retusa* (.25 mm portion). These seeds are typical of the dietary combinations in Pueblo III (Reinhard 2006; Sutton and Reinhard 1995). (See ethnobotanical associations of *Amaranthus* in Table 8.10, p. 282). More uncharred cheno-am seeds and an uncharred purslane seed in this portion attest to good preservation conditions. Ground maize and cheno-am are with pre-harvest maize cuisine that includes finely ground maize and wild seeds (Sutton and Reinhard 1995). Underdeveloped Sand Canyon *Malva*-type fruits indicate that the plant was used perhaps for its leaves and roots, Moerman (1998:334-335) records the ethnographic use of *Malva* sp. leaves with flour. *Malva* fruits are available in the summer and fall also indicative of a pre-maize harvest timing. A fragmented two-hand mano was recovered in the fill another of the three firepits in the room. A corner bin suggests the room was used for food storage. Although informal, at least one of the firepits showed evidence of multiple burn events and clean-outs and was left empty (CCAC 2004, Rooms, Structure 1002).

Artemisia tridentata (.71 mm portion). As with the SC1 sample, big sagebrush wood was not observed in the larger light fraction screens. The presence of remains of this charcoal from inside a room indicates a deliberate discard here. There is no evidence to suggest that the roof was burned and that big sagebrush was present for this reason.

Monocotyledon stems (.71 mm portion). The minute and fragmented nature of these specimens suggests that they may be Poaceae stems. Inferences include waste from the use of grass seeds, as fire starter or discarded as part of another activity.

Sand Canyon *Malva*-type fruit schizocarp (.71 mm and .25 mm portions). These specimens are approximately 1 mm in diameter as compared to the typical 5 mm diameter of modern comparative Malvaceae fruits and likely represent early development of the fruit. Considered a Eurasian import and nonnative species, mallow are disturbance plants (Royer and Dickinson 1999:233). Findings here suggest that mallow is not an non-native plant to the Southwest. Moerman (1998:334-335) records various species of Malvaceae as a drug and as food.

Sample SC3: west kiva 1502 corner room 1527 (upper storey firepit)

Sample SC3 (PD 1543, FS 1) was excavated from a firepit (feature 7) in room 1527, the upper story of kiva corner room 1519/1527 located in the west half (kiva 1502) of D-shaped bi-walled building. This room was only partially excavated but notable for its association with the later less elaborate west kiva and presence of green pigment in its lowermost surface. Three surfaces were identified in the room (chapter seven, p. 227). Room 1527 was thought to have fallen into disuse prior to abandonment of the pueblo (CCAC 2004, Rooms, Structure 1527), the transition had to have occurred some time after completion of the kiva (ca. A.D. 1270-71) and a series of replastering episodes of which there were at least four in the west kiva (Kuckelman et al. 2007:para. 156). If the historic record is any indication these events could signal annual refurbishing. If so, this would situate last uses of the original purpose of the D-shaped building around A.D. 1274-75.

The firepit was dug into construction fill on the latest surface (surface 1). It was irregular in plan view and basin-shaped in cross section, a depth measurement of 7 cm is inferred. Charred maize kernels were present in the fill (CCAC 2004: rooms, structure 1527). No faunal remains are identified. No artifacts were associated with the exposed floor. The space was re-used for refuse. Abundant artifacts and a broken up burned spot accumulated over a period of time. Due to partial excavation, access to the room is unknown. Original sample details are outlined in Table 9.6.

Table 9.6 SC3 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	**Light fraction retained**	**Light fraction originally examined**	**No. of subsamples scanned (original data)**		**Original identified sample content**
			.71 mm	**.25 mm**	
1000 ml	75 ml	66 ml	3 (2.7 ml)	3 (.9 ml)	*Juniperus* charcoal, *J. osteosperma* scale twig *Pinus* (pine unspecified) charcoal *Artemisia tridentata* (big sagebrush) charcoal *Cercocarpus* (mountain mahogany) charcoal *Purshia* (cliffrose/bitterbrush) charcoal *Zea mays* (cobs, 40 cupules, 51 kernels) *Physalis longifolia* seeds *Opuntia* (prickly pear) cactus seeds Seeds, unknown (>2.8 mm in size)

New taxa not previously observed were identified in the remaining unexamined residua of sample SC3, described by portion. Data are recorded in Appendices G (Table G.3) and H (Table H.3). Accumulation curves are plotted in Appendix H.

.71 mm portion

The unexamined volume of this portion measured 9.5 ml and contained seven new taxa/parts in the first five subsamples that add another wood type, domesticate parts and wild seeds. Previously identified maize cupules and kernels found in the larger portions were also recovered. New maize remains include glumes, glume fragments, kernel fragments and kernel embryos with obvious growing tips (photographs D.1 to D.3, Appendix D). Glumes and kernel embryos are counted as additional new "taxa" (parts) based on inferences of ground maize and processing during a late stage of kernel development. Wild plants include cheno-am and *Bromus* (brome grass, subfamily Pooideae, photograph D.29, Appendix D). I identified *Quercus* (oak) charcoal, likely Gambel's oak (*Quercus gambelii*). *Artemisia tridentata* charcoal remains and an unidentifiable unknown wood with a lenticular surface similar to *A. tridentata* were present. A comparatively large quantity of sagebrush flowering heads counted as a new taxa based on an inference for season of use and unique part. There was abundant tissue "type 5" specimens that I infer as ground maize (epidermis).

25 mm portion

The previously unexamined residua measured 7.2 ml. Two to three new taxa were recovered in tenth (twelfth) and twentieth subsamples of a total of 24 subsamples for this portion. New taxa are presented in subsample order in Table 9.7 (over).

Table 9.7 Recovery of charred taxa by subsample number, firepit sample SC3 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
1	*Pinus*-type	pine	bark scale	1
1	*Physalis longifolia*-type	common groundcherry	seed	1
1	*Zea mays*	maize/corn	cupule fragment	1
1	*Zea mays*	maize/corn	kernel fragment	1
1	*Zea mays*	maize/corn	kernel embryo	2
2	*Zea mays*	maize/corn	glume fragment	1
2	*Zea mays*	maize/corn	kernel fragment	1
2	*Artemisia tridentata*-type	big sagebrush	flowering head	1
2	*Pinus*-type	pine	bark scale	1
2	*Zea mays*	maize/corn	kernel embryo	1
2	*Artemisia tridentata*-type	big sagebrush	charcoal	1
3	*Zea mays*	maize/corn	kernel fragment	1
3	*Zea mays*	maize/corn	glume fragment	>1
3	Cheno-am type	goosefoot/pigweed	seed	1
3	*Artemisia tridentata*-type	big sagebrush	flowering head	3
4	*Zea mays*	maize/corn	kernel embryo	1
4	*Zea mays*	maize/corn	glume fragment	2
4	*Artemisia tridentata*-type	big sagebrush	flowering head	3
4	*Physalis longifolia*-type	common groundcherry	seed	1
5	*Zea mays*	maize/corn	kernel embryo	1
5	*Bromus*-type	brome grass	caryopsis	1
5	*Zea mays*	maize/corn	glume fragment	1
5	*Artemisia tridentata*-type	big sagebrush	flowering head	1
5	*Quercus*-type (cf)	oak	charcoal	1
6	*Zea mays*	maize/corn	glume	2
7	*Zea mays*	maize/corn	kernel	1
7	*Zea mays*	maize/corn	kernel embryo	1
7	*Physalis longifolia*-type	common groundcherry	seed	1
8	*Zea mays*	maize/corn	cupule fragment	1
9	*Zea mays*	maize/corn	kernel embryo	1
9	*Physalis longifolia*-type	common groundcherry	seed	1
10	*Zea mays*	maize/corn	kernel embryo	3
10	*Physalis longifolia*-type	common groundcherry	seed	1
10	*Artemisia tridentata*-type	big sagebrush	flowering head	1
11	*Zea mays*	maize/corn	glume fragment	1
12	*Physalis longifolia*-type	common groundcherry	seed	1
12	*Zea mays*	maize/corn	cupule	1
13	*Artemisia tridentata*-type	big sagebrush	flowering head	1
13	*Zea mays*	maize/corn	kernel embryo	1
		.25 mm		
3	*Zea mays*	maize/corn	kernel embryo	1
7	*Artemisia tridentata*-type	big sagebrush	flowering head	1
8	*Artemisia tridentata*-type	big sagebrush	flowering head	1
8	*Zea mays*	maize/corn	kernel embryo	1
10	Cheno-am	goosefoot/pigweed	seed	1
10	Poaceae-type caryopsis	grass	caryopsis	1
11	*Zea mays*	maize/corn	kernel embryo	1
11	*Artemisia tridentata*-type	big sagebrush	flowering head	1
12	*Artemisia tridentata*-type	big sagebrush	flowering head	1
12	*Zea mays*	maize/corn	kernel embryo	2
12	Poaceae-type floret	grass	floret	1
13	*Zea mays*	maize/corn	kernel embryo	1

continued…

Table 9.7 Recovery of charred taxa by subsample number, firepit sample SC3 (new taxa shaded), continued.

Subsample	Taxon	Common name	Part	No. of specimens
16	*Zea mays*	maize/corn	kernel embryo	1
18	*Artemisia tridentata*-type	big sagebrush	flowering head	1
20	*Portulaca retusa*-type seed	purslane	seed	1
21	*Portulaca retusa*-type seed	purslane	seed	1
21	*Zea mays*	maize/corn	kernel embryo	1

New taxa are wild food-type resources and consist of an unknown charred Poaceae (grass type unknown) caryopsis, unknown Poaceae floret, and *Portulaca retusa* seeds for the .25 mm screen. Additional *Artemisia tridentata* flowering heads were also found. Few charred botanical remains are noted with the exception of distinctive buds and an unidentified leaf. Nonbotanical and other specimens consist of uncharred insect remains and uncharred seeds of cheno-am and purslane that could be ancient. Additional evidence of maize remains such as kernel embryos support an inference of finely ground maize (flour) in this location. Generally both portion sizes were littered with maize kernel and glume fragments. Maize may be also reflected in the multiple unknown tissue types found in .71 mm portion. No obvious modern disturbance is recorded in the field notes for this deposit and there is both charred and uncharred insect evidence in this portion. The .25 mm portion also contained unique charred tissues, buds and charcoal. Nonbotanical and other-type remains include an adobe fragments, fecal pellets, unknown twigs, and coloured fibers (modern contamination?). Several uncharred seeds of cheno-am and *Physalis longifolia* are presumed ancient. I suggest interpretative potential of new taxa by specimen type:

Artemisia tridentata. Two specimens of *Artemisia tridentata* charcoal and fifteen flowering heads identified in this sample could be the result of burning big sagebrush wood as a fuel but may also represent deliberate discard of unwanted materials for other purposes. Big sagebrush flower buds or flowering heads are rarely recorded for Sand Canyon Locality sites. Sand Canyon Pueblo samples yielded one specimen from midden 1214.[108] The size and fragility of sagebrush flowers may explain their apparent rarity.

Bromus. Brome grass is a new grass type for SCP. Very little evidence of charred grass remains has been recorded with the exception of a festucoid-type caryopsis found in a sample from

[108] A single big sagebrush flowering head is noted for Lillian's Site found in a hearth flotation sample excavated from a Pueblo III kiva occupation (Adams, K.R., 1999). Another single specimen was recovered from hearth and floor of the massive-walled Troy's Tower located nearby. Troy's Tower is unusual with subterranean features and possibly an adjunct defensive role for Sand Canyon Pueblo (Varien 1999). Hearth and floor ash samples there contained seeds of *Cycloloma atriplicifolium* (winged pigweed), *Mentzelia albicaulis* (blazingstar/stickleaf), Opuntia (prickly pear cactus), *Plantago* (wholly wheat/plantain) and an unidentified

room 512 notable for its stone mortar. Grass caryopses are difficult if not impossible to identify due to the enormous variety and similarity of grass types. Grass grains were an important contribution to the diet and the Hopi recognized at least six major categories of grasses: *tu:´saka*, a term that applies to grasses and many other herbs; *s_3´h_3*, applied to *Hilaria jamesii* (Torr.) Benth. or galleta grass; *pa´sh_3* and *pa´tusaka* for grasses that grows near water; *tupe´ls_3h_3*, for grass growing among rocks; and *mumu´ri*, for any grass-like plant with round stems and leaves growing near water. Twenty-five species of grasses were named and used by the historic Hopi (Whiting 1939:64). The best example of grass remains found at Sand Canyon Pueblo was located in the lower story east bi-wall room 1507 (chapter seven, p. 228-229). This accumulation is noted for its grass, twigs and cob impressions. The room most likely served as a space for the collection of dried shrubs and other materials for use in the east kiva (1501). Specimens of grasses, including stem fragments likely find their way into the smallest particle sizes and may be missed.

Quercus. Only 11 specimens of oak charcoal are recorded in the CCAC (2015a) database, these were recovered from macrofossil sample hand-picked from kiva 102 (the "*Cleome*" kiva which also contained an uncharred *Quercus* nut) and a single charcoal specimen from the kiva hearth (see sample analysis SC4 to follow). Oak is recorded for block 200 (room 204, midden 209) and block 500 (the single oak charcoal specimen was recovered from a flotation sample taken from a floor surface in the "mortar" room in block 500 (room 512, chapter seven, p. 198). Oak charcoal was found beneath the surface of courtyard 1000 and in the lower storey of east kiva room 1507 (see above).

Historically, oak was used for planting sticks (Whiting 1939:14), rabbit hunting sticks (23) in the making of ceremonial objects (28). Oak features as a Hopi clan name (*kwi:΄ngvi*)(47). Weaponry made of *kwi:΄ngvi* includes arrows, bows, clubs, weft batons, axe handles and utensils (Hough 1918). *Kwi:΄ngvi* is associated with the northwest direction in the Oaqol/*Owaquöl*, *Lakon* or *Maraw* ceremonies (Whitely 1988:59). According to Voth (1905a), *Owaquöl* like *Lakon* are called "Basket Dances," are considered second-order societies and celebrate "fertility and harvest"(59). *Owaquöl* occurred historically in odd years between September and October and is owned by the Sand Clan.[109]

New taxa accounted for in previously unexamined sediments in the smallest particle sized screens, increased the taxonomic richness of sample SC3 to 17 charred taxa. Nine of these were

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Capparaceae (Caper family/*Cleome* [?]) seed, similar findings to that of tower 101 at SCP. All species are sophisticated ethnomedicines with scientifically proven pharmacological activity (see chapter eleven).

[109] Whitely (1988) writes of the renewal of the *Owaquöl* or Basket Dance in the 1980s at Bacavi on Third Mesa that traces its origins to the Orayvi split in 1906 (5). "This was [a] notable renewal since in former times, the *Owaquölt* was a religious society requiring initiation, and since Bacavi's previous performance had been in the early 1920s. As with the Buffalo Dance, some of the same songs were taken from the previous performance,

previously identified in the original analysis; eight identified through complete analysis. With additional subsampling new taxa indicate that 47 per cent of the known sample's richness was available in the unexamined .71 mm and .25 mm portion volumes, thirty-five per cent in the .71 mm screen. New taxa suggest that finely ground maize, wild seeds such as cheno-am and common groundcherry were used, processed (?) and/or discarded here. Unique and new identifications such as big sagebrush flowering heads places use in the spring and summer months when milled maize cuisine (Sutton and Reinhard 1995) would be expected if stores were low and fresh maize was still unavailable. The flowering heads may also indicate an activity requiring sagebrush branches at a particular season of use. The flexible minimal volume standardized in the SAC approach fails to capture the richness of the smallest particle sizes and the interpretative potential of the sample is significantly underestimated through subsampling, particularly the .71 mm screen. When observations are plotted on species accumulation curves for the sample, charred taxa accumulated rapidly in the initial sampling phases of the re-analysis of the .71 mm screen, in all other categories and in the .25 mm portion, observations are staggered throughout (Figures H.3a, H.3b and Table H.3, Appendix H).

Sample SC4: *Cleome* kiva 102 (hearth)

Species-area curve sample SC4 (PD 147, FS 4) came from the central hearth in kiva l02 (CCAC 2004: Kivas, Structure 102; chapter seven pp. 183-185). The hearth content is expected to contain at least some evidence of residential meals and based on the timing of the final attack, could provide evidence of a last meal.

The hearth was built into underlying bedrock and lined with mud and was elliptical in shape. Three stone slabs held in place with mud plaster were found centrally located *in situ*. Measuring 72 cm in length, 65 cm in width and 21 cm in depth, the hearth was fire-reddened and charred and was not used after the raid. After a period of time passed, the feature was sealed with washed-in sediment. Later, the roof of the kiva was burned and the structure eventually collapsed (CCAC 2004: Kivas, Structure 102). Table 9.8 (over) outlines sample data from the previous analysis. On analysis of the previously unexamined material, I identified seven new taxa (Table 9.8, over). Data are recorded in Appendices G (Table G.4) and H (Table H.4). Accumulation curves are plotted in Figures H.4a and H.4b (Appendix H).

suggesting a remarkable persistence over time (and without ceremonial context) or oral literature in song." (194-195). By Parson's time, the ceremony was still active, but changed. Anyone could perform (Parsons 1922:291) and "lack of priestly roles and esoteric ritual practice" was no longer evident (Whitely 1988:276). The persistence of the performance even in the face of long-term nonperformance is a Pueblo characteristic that provides clues to enduring connections that may exist between archaeological and historical past.

Table 9.8 SC4 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	Light fraction retained	Light fraction originally examined	No. of subsamples scanned (original data) .71 mm	.25 mm	Original identified sample content
1000 ml	82 ml	70 ml	3 (2.7 ml)	3 (.9 ml)	*Juniperus* charcoal *Pinus* (pine unspecified) charcoal *Cercocarpus* (mountain mahogany) charcoal *Quercus* (oak) charcoal *Zea mays* (cobs, cupules)

.71 mm portion

The previously unexamined material measured approximately 14 ml. I identified six new taxa in the first, third, seventh, eleventh and thirteenth subsamples. Two new wood types consist of *Artemisia tridentata* (multiple charcoal specimens), and a Utah juniper scale leaf and twig. Wild seeds include cheno-am, *Nicotiana* (tobacco), *Physalis longifolia*, and *Portulaca retusa*. This portion also contains numerous unknown but distinctive botanical fragments that continue to accumulate throughout consisting of unidentified wood types, overwintering buds and unknown tissue. Nonbotanical/Other occurrences are sparse, for the most part consisting of a small amount of uncharred insect remains (Table 9.9).

Table 9.9 Recovery of charred taxa by subsample number, firepit sample SC4 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
1	*Physalis longifolia*-type	common groundcherry	seed	1
1	*Pinus*-type	pine	bark scale	1
3	*Artemisia tridentata*-type (cf)	sagebrush	charcoal	1
3	*Portulaca retusa*-type	purslane	seed	1
5	*Artemisia tridentata*-type (cf)	sagebrush	charcoal	1
7	*Pinus*-type	pine	bark scale	1
7	*Nicotiana*-type	tobacco	seed	1
10	*Pinus*-type	pine	bark scale	1
11	Cheno-am	goosefoot/pigweed	seed	1
13	*Juniperus osteosperma*-type	Utah juniper	twig	1
17	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
17	*Pinus*-type	pine	bark scale	1
		.25 mm		
15	*Pinus*-type	pine	bark scale	1
17	Cheno-am	goosefoot/pigweed	embryo	1
17	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
17	Monocotyledon-type	monocotyledon	fvb[a]	1
18	*Pinus*-type	pine	bark scale	1
19	*Pinus*-type	pine	bark scale	1
20	*Pinus*-type	pine	bark scale	1
21	*Pinus*-type	pine	bark scale	1
23	Monocotyledon-type	monocotyledon	fvb	1
24	Monocotyledon-type	monocotyledon	fvb	1
32	*Portulaca retusa*-type	purslane	seed	1

Notes:
[a] Fibrovascular bundle.

.25 mm portion

The unexamined .25 mm portion measured 11.0 ml. I found one new taxon (a monocotyledon fibrovascular bundle ("fvb") in the seventeenth subsample of this volume. Inferred to represent a wild plant resource of unknown use, this identification is of little interpretative value. FVBs found in yucca (*Yucca*) leaves were used as durable and strong fiber. I saw no other evidence of yucca or other monocots. Other materials in this portion included botanical unknowns (leaf, buds, tissue) and nonbotanical/other-type remains consisting of a minor amount of uncharred insect parts.

Using this data, sample SC4 contained twelve taxa; five were observed in the original analysis, a further seven found in the previously unexamined smallest screens. The larger particle sizes (4.75 mm, 2.8 mm and 1.4 mm) yielded 42 per cent of taxa, 58 per cent of the available taxonomic richness missed due to subsampling. The .71 mm screen was productive for half. The .25 mm screen is abundant in sediment, requiring the scanning of 17 subsamples to successfully recover a final new taxon of negligible interpretative value. With the identification of common groundcherry in the .71 mm screen season of use could be attributed to fall and prior or around maize harvest. This is supported by the apparent absence of maize kernels, maize may have been harvested by mid October in the area around Sand Canyon Pueblo (Adams et al. 2006). The interpretation of this hearth is enhanced with additional subsampling in the .71 mm portion. The presence of tobacco present in a kiva hearth assessed as a final abandonment context is particularly intriguing.

<u>*Nicotiana.*</u> Tobacco seeds have not been observed for SCP previous to these findings, possibly due to subsampling, the seeds are minute. The presence of this species in a hearth deposit is unexpected based on what is known about the typical remains in hearths at SCP. Wild tobacco is native to the southwestern U.S., Mexico and parts of South America and thrives in disturbed habitats, particularly after fire events (Bush 2002). It is a sacred plant to indigenous people throughout the Americas (Moerman 1998). *Nicotiana* is a particularly interesting plant choice in light of the final warfare event, the concern for safety, the need for medicines and apparent clan leadership associations in this "gateway" block. I also recovered *Nicotiana* from a midden 1214 sample and in a sample collected from the west kiva bi-wall room 1513. Historic connections with cloud tobacco, wind, snow [Bear and Sandhill Crane clan medicine seed as documented by Cushing (1920)] and the War Gods (Bunzel 1932:486, 487; Cushing 1920) seem to confirm that the use of tobacco was culturally contextual, associated with "prayer, protection, reverence and healing" (Bush 2002). The minute size of the seed likely plays a role in poor recovery, sorting into the smallest and subsampled screen. In this sample, the SAC minimal volume was unsuccessful in estimating the botanical richness of the sample and did not account for new and culturally important taxa.

Sample SC5: *test trench kiva* 600 (hearth)

Sample SC5 (PD 1582, FS 4) was collected from the fill of a formally constructed hearth partially excavated and located in this aboveground kiva (CCAC 2004 Structure 600). Little is known about this kiva due to limited excavations. Like its neighbour, kiva 602, it is possible that it was abandoned as a result of the final warfare event. The hearth was dug into a clay deposit under the floor and the walls and rim were lined with adobe. It was remodeled at some point. Only the southwest edge of the feature was uncovered, the remainder being outside of the excavation unit. Measuring (incomplete) at 70 cm in length, 66 cm in width and 25 cm in depth, the contents were mixed with debris from a rodent burrow. A fragment of a metate, scant charcoal and adobe were present along with the skeletal remains of a rodent. Two vegetal samples were recovered from the hearth identified as *Juniperus* and *Pinus* charcoal. The final meal in this hearth included the remains of squirrels (Sciuridae) and small mammals (jackrabbit size or smaller). After the final use of the kiva, part of the roof collapsed and then it was burned (CCAC 2004: Kivas, Structure 600; chapter seven, p. 199 here). I identified three new taxa in the unexamined portions. Table 9.10 outlines sample data from the previous analysis. Data are recorded in Appendices G (Table G.5) and H (Table H.5). Accumulation curves are plotted in Figures H.5a and H.5b (Appendix H).

Table 9.10 SC5 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	**Light fraction retained**	**Light fraction originally examined**	**No. of subsamples scanned (original data)** .71 mm	.25 mm	**Original identified sample content**
1000 ml	17 ml	16 ml	3 (2.7 ml)	unclear, presumed 3 (.9 ml)	*Juniperus* charcoal

.71 mm portion

The previously unexamined volume measured 5.0 ml. Two new taxa were recovered in the first and third subsample consisting of *Cercocarpus* charcoal and *Juniperus osteosperma* twigs and scale leaves. Unidentified botanical remains were limited to a few tissues and an unknown bud. Uncharred disseminules and a single uncharred fecal pellet make up the nonbotanical/other content. Unknown botanical remains were distributed throughout the sample.

.25 mm portion

The unexamined residua for the .25 mm portion measured 2.5 ml. I found one new taxa, cheno-am, in my first subsample. Distinctive but unidentified botanical remains were few, consisting of wood fragments and one unknown charred disseminule. Nonbotanical/other-type occurrences consist of charred bone, insect remains, and a few uncharred disseminules. New taxa identified in both the .71 and .25 mm portions are recorded in Table 9.11 (over).

Table 9.11 Recovery of charred taxa by subsample number, firepit sample SC5 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
2	*Cercocarpus*-type	mountain mahogany	charcoal	1
3	*Juniperus osteosperma*-type	Utah juniper	scale leaf	3
3	*Juniperus osteosperma*-type	Utah juniper	twig	>1
3	*Juniperus osteosperma*-type	Utah juniper	twig (vitrified)	>1
		.25 mm		
1	Cheno-am	goosefoot/pigweed	seed	1
9	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1

Low occurrences of taxa, botanical, and other remains, suggest that the hearth appears cleaned after its last use, excavation was too limited, or the burning of the kiva roof consumed any plants present. SC5 is interesting for its very low incidence of uncharred or insect or other disturbance evidence, making it one of a few samples that suggest the feature was almost completely undisturbed even in light of the rodent remains. With part of the feature outside the excavation unit it is difficult to make a case for either abundance or lack of plant remains. Using the data collected here, the sample contained at least four recoverable and identifiable taxa based on full examination of the two smallest portions. Seventy-five per cent of the available taxa were distributed in the two smallest particle screens. The SAC approach was unsuccessful in capturing any taxa in the .71 and .25 mm screens. Depending on how much inference value is associated with the new taxa there may not be enough interpretative potential to support additional subsampling especially in light of a partial excavation. In addition to these scant findings, fragments and bones of a squirrel or squirrels and a few bones of an animal of jackrabbit-sized or smaller were found in the hearth fill suggesting a final meal possibly included *Chenopodium* or *Amaranthus*. The apparent absence of edible food remains can also be attributed to the rodent although when this creature took up residence is unknown.

Secondary refuse: trash accumulations

<u>Sample SC6: *Kokopelli kiva midden* (109)</u>

Sample SC6 (PD 786, FS 8) was collected from midden 109 (CCAC 2004: Middens, Nonstructure 109; chapter seven, p. 186) associated with the kiva 108 noted for its pecked *Kokopelli* figure. It consisted of domestic trash (undescribed) and a "modest number of artifacts" (CCAC 2004: Middens, Nonstructure 109). Only a portion of the midden was excavated. SC6 was collected from segment 2, four strata below modern ground surface and wall fall (dimensions unclear) on the same surface as the original kiva floor. Although the midden and adjacent structure (kiva 102) are inferred as constructed during a late occupation period, A.D. 1271, 1274 or later (CCAC 2004: Middens, Nonstructure 109); the SC6 sample came from below construction debris, fill and layers of wall fall. If the plastering over of the *Kokopelli* petroglyph is any indication, the A.D. 1250s or 1260s may be represented. I see that event as reflecting a transition in the use of the kiva possible due to the original user group leaving the village. Alternatively, the midden may be late construction debris, fill and wall fall from the collapse of the building after abandonment

The recovered specimens from the original analysis were re-screened and I estimate that Utah juniper and cheno-am were recovered in the .25 mm screen based on the volume of material originally examined for the .25 mm screen (9 subsamples). The previously unexamined residua yielded one new taxon, a single grass caryopsis (Poaceae/festucoid-type), which I recovered in the third subsample of the .71 mm portion size (Table 9.12). Data are recorded in Appendices G (Table G.6) and H (Table H.6). Accumulation curves are plotted in Figures H.6a and H.6b (Appendix H).

Table 9.12 SC6 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	**Light fraction retained**	**Light fraction originally examined**	**No. of subsamples scanned (original data)**		**Original identified sample content**
			.71 mm	**.25 mm**	
1000 ml	60 ml	52 ml	3 (2.7 ml)	9 (2.7 ml)	*Juniperus* charcoal, *J. osteosperma* scale leaf, twig *Pinus* (pine unspecified) charcoal and bark scales *Prunus/Rosa* (chokecherry/rose) charcoal *Zea mays* cob fragments cheno-am seed

.71 mm portion

The unexamined residua of the .71 mm portion measured 5 ml. The new taxon (a festucoid grass caryopsis) was recovered in the third subsample of this volume. There is a quantity of unidentified but morphologically distinct botanical remains consisting of various buds, disseminules and tissues (many compare favourably to kernel coat fragments [“tissue, type 5”]). Nonbotanical and other remains are uncharred and consist of two different immature seed types, one spurge-like (*Croton*) and the other is round but without distinguishing characteristics (details in Appendix C and shown in photographs D.79 and D.91, Appendix D). Uncharred insect remains, grasses and juniper twigs are also present.

25 mm portion

The unexamined volume measured 2.7 ml. I observed additional charred Poaceae/festucoid-type caryopses and based solely on size, could be the same type as found in the .71 mm screen. Unidentified botanical and nonbotanical/other-type remains consisted of uncharred grass caryopses (festucoid-type uncharred, potentially ancient in origin based on the charred findings of same), an unknown bud, a few charred insect parts and black spherical bodies. Taxa are detailed by order of observation for both screens in Table 9.13 (over).

Table 9.13 Recovery of charred taxa by subsample number, firepit sample SC6 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
1	*Pinus*-type	pine	bark scale	1
2	Cheno-am	goosefoot/pigweed	seed	1
2	*Pinus*-type	pine	bark scale	1
3	Poaceae (festucoid-type)	festucoid grass	caryopsis	1
3	*Juniperus osteosperma*-type	Utah juniper	scale leaf	4
3	*Pinus*-type	pine	bark scale	1
4	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
4	*Pinus*-type	pine	bark scale	1
5	Poaceae (festucoid)-type	festucoid grass	caryopsis	1
5	*Pinus*-type	pine	bark scale	2
		.25 mm		
1	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
2	Cheno-am	goosefoot/pigweed	seed	1
2	Poaceae (festucoid)-type	festucoid grass	caryopsis	1
4	*Pinus*-type	pine	bark scale	2
6	Poaceae (festucoid)-type	festucoid grass	caryopsis	1

Combining the original and new results, SC6 contained seven taxa in all; four were recovered in the larger unsubsampled portion sizes during the original analysis. Three taxa were found in the smallest portions, or 43 per cent of identifiable taxa present in these smallest screens. The SAC flexible minimal volume and stopping point was successful for capturing two of the three new taxa but sediment volumes are low for this sample and good results are not unexpected. New information was gained from the examination and depending on the research value assessed. Grass grains were a typical component of Pueblo III diet. New observations plotted in accumulation/area curves suggest distribution is unpredictable (Appendix H).

<u>Sample SC7 also known as CV12: *broken ladle midden* 515</u>

Excavated from a midden located in the "subterranean kiva" block 500 (CCAC 2004, Nonstructure 515), SC7 (PD 701, FS 41) is also evaluated in the bulk volume comparison, SC7 is CV12 and further analyzed here. I have characterized the deposit as the "broken ladle midden" for its discarded decorated ladle. The characterization does not do credit to the kiva suite that is distinguished by its subterranean kiva, unusual artifacts (*tchamahias* and rare mortar) and its early construction dates. Depositional detail of this deposit can be found in chapter seven (p. 198; a bulk volume sample was also assessed for this deposit in chapter eight, pp. 292-294). The midden was only partially excavated and exposed in a trench. A collection of artifacts and large pieces of wall fall were observed in the first strata. The depth of the accumulation is unclear but overlays another cultural level thought to be construction fill above bedrock. Investigators inferred that the midden was in use throughout the occupation and discontinued at the abandonment of the block and the depopulation of the village (CCAC 2004: middens, nonstructure 515). The sample was collected from one stratum above bedrock from the center of the midden. Stratigraphic placement and early dates associated with both block 500 and the great kiva nearby suggest to me that deposition occurred in the A.D. 1250s or 1260s reflecting a pre-drought timing and, presumably, "normal" activities and discard (Table 9.14).

Table 9.14 SC7 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	**Light fraction retained**	**Light fraction originally examined**	**No. of subsamples scanned (original data)**		**Original identified sample content**
			.71 mm	**.25 mm**	
1000 ml	68 ml	54 ml	4 (3.6 ml)	5 (1.5 ml)	*Juniperus* charcoal *Pinus* (pine unspecified) charcoal, bark scales *Prunus/Rosa* (chokecherry/rose) charcoal *Zea mays* cupules

The following taxa were identified for the previously unexamined portions. I identified a single new taxon, *Portulaca retusa* in the unexamined residua of the .25 mm portion. Data are recorded for this sample in Appendices G (Table G.7) and H (Table H.7). Accumulation curves are plotted in Figures H.7a and H.7b (Appendix H).

.71 mm portion

The unexamined volume of the .71 mm portion measured 8.3 ml. I identified a *Chenopodium* seed in the fourth subsample. A quantity of uncharred *Chenopodium* and *Chenopodium-Amaranthus*-type seeds and seedcoats are also present. I observed no other plant remains, only uncharred insect parts. With scant other evidence to suggest modern disturbance and much evidence in support of ancient uncharred materials, it is plausible that the cheno-am seeds are ancient.

.25 mm portion

The unexamined volume for the .25 mm portion measured 3.9 ml. Five consecutive subsamples were scanned in the initial analysis suggesting the recovery of a new taxon in the second subsample. The new taxon is either a pine bark scale or a maize cupule fragment. A single new taxon, *Portulaca retusa*, is inferred to represent a wild food resource. The portion also contained charred unknown disseminules, black spherical bodies, and a termite fecal pellet suggesting the burning of termite infested wood. Uncharred materials include unknown disseminules, insect parts and pellets.

For this sample I re-examined the previously examined portion of the .25 mm screen to see if more *Chenopodium* seeds were present or if I could identify the uncharred remains to this genera. I found no other evidence of *Chenopodium*. I did observe a minute charred seed that compares in size and general shape with the rush (*Juncus*)(photograph D.23, Appendix D). If the specimen is a rush type, presence of *Juncus balticus* (wirerush) in the area (Gish 1990:11) supports the possibility that the plant may have been present in the past. *Juncus* was tentatively identified at Yellow Jacket Pueblo (two specimens). Rush is historically aligned with ceremonies associated with water (Moerman 1998) (Table 9.15).

Table 9.15 Recovery of charred taxa by subsample number, sample SC7 (new taxa shaded).

Subsample	**Taxon**	**Common name**	**Part**	**No. of specimens**
		.71 mm		
2	*Pinus*-type	pine	bark scale	>1
3	*Pinus*-type	pine	bark scale	>1
4	*Pinus*-type	pine	bark scale	>1
4	*Chenopodium*-type	goosefoot	seed	1
6	*Pinus*-type	pine	bark scale	>1
7	*Pinus*-type	pine	bark scale	>1
8	*Pinus*-type	pine	bark scale	>1
9	*Pinus*-type	pine	bark scale	>1
		.25 mm		
4	*Portulaca retusa*-type	purslane	seed	2
8	*Pinus*-type	pine	bark scale	3

Chenopodium is a rarely identified genera, typically classified as "cheno-am" because of problems with clearly identifiable traits to distinguish the seeds from *Amaranthus*. The SCP record prior to this analysis is an uncharred *Chenopodium* leaf (CCAC 2015a) found in the roof fall and refuse of "*Cleome* kiva" (102) although cheno-am seeds are found in caches (in block 100 and elsewhere). Eight taxa, including termite evidence and *Juncus* are the known population for this sample. Approximately 62 per cent of the identified content was found in the larger unsubsampled portions, none are seed remains. Charred and uncharred *Chenopodium,* cheno-am and *Portulaca retusa* are important additions. When using ubiquity measures for inference potential, these specimens add to the previous 38 seed count for purslane and new identification of goosefoot seed content for SCP. This adds another midden to the record of trash accumulations that contain wild, summer-season seeds. As an early deposit, this content is consistent with similar evidence from the later and latest periods of occupation. Termite evidence indicates termite infestation was present in the early years (circa A.D. 1250s) and likely contributed to the need for new construction beams throughout the occupation. I suggest that termite evidence is a plausible explanation for the range of tree-ring cutting dates across the site. In this respect, termites provide inference potential for earlier initial construction at SCP and later repair.

When considering the additional sample (FV12) evaluated for this midden, a more complete picture of early plant use is also achieved. FV12 contained a wide variety of charcoal evidence: *Pinus* e*dulis* (pinyon pine), *Chrysothamnus* (rabbitbrush), *Purshia mexicana* (cliffrose) and/or evidence of *Purshia tridentata* (bitterbrush) remains and includes wild plant remains in the form of uncharred cheno-am seeds and *Yucca baccata*-type (Datil yucca) (pod). Goosefoot, purslane and termite evidence is accounted for only in the complete analysis of the smallest particle sized portions of sample SC7. In this case, an additional sample (FV12) provided new taxa but did not account for small wild seed evidence. Subsampling the smallest light fraction screens is at least one cause for low visibility of small specimens. Data plotted demonstrate observations of new taxa occur fairly early in the subsampling process for this sample.

<u>Sample SC8 also known as CV13b: Great kiva midden 803</u>

Sample SC8 (PD 1008, FS 113) was collected from the great kiva midden (nonstructure 803). The midden was encountered in an excavation unit in an area that was either a peripheral room, designed to be a peripheral room but not constructed, or was an open area. Because of limited excavation several explanations are plausible for this accumulation: 1) the great kiva peripheral rooms were designed to completely encircle the great kiva, and the midden is trash dumped in one; 2) the peripheral room configuration was not completed and the trash here represents discard during construction; and 3) the disordered use of the great kiva in later years prompted accumulation of trash here because normal great kiva activity had been suspended or diminished. I have estimated the deposition as accumulating in the (late) A.D. 1270s, a decade I have associated with transitions and changes in the use of the great kiva from what is presumed communal ceremony. The additional sample evaluated for the midden (FV13) and its comparison volumes, CV13a and b) provides additional evidence that a variety of domesticates and wild plants were discarded in the midden (chapter eight, pp. 295-297). Depositional details are documented in chapter seven (p. 205)(Table 9.16)

Table 9.16 SC8 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	**Light fraction retained**	**Light fraction originally examined**	**No. of subsamples scanned (original data)**		
			.71 mm	**.25 mm**	**Original identified sample content**
1000 ml	44 ml	37 ml	3 (2.7 ml)	3 (.9 ml)	*Juniperus* charcoal *Pinus* (pine unspecified) charcoal *Amelanchier/Peraphyllum* (serviceberry/peraphyllum) charcoal *Cercocarpus* (mountain mahogany) charcoal *Zea mays* (kernel and cupules) unidentified fruit rind (*Cucurbita?*)

The SC8/CV13b sample was collected from sediments in the second stratum of the midden of unspecified depth, below wall fall and above indeterminate fill. Seven taxa are assumed by me as recovered in the larger screen sizes. These are interpreted to represent fuel wood, tinder and domesticated food resources. Three charred unknown fecal pellets (>.71 mm in size) are noted. Both the .71 and .25 mm screens were subsampled three consecutive times and presumably no new taxa were recovered in either screen. In my examination of the unexamined residua I observed four new taxa.). Data are recorded in Appendices G (Table G.8) and H (Table H.8). Accumulation curves are plotted in Figures H.8a and H.8b (Appendix H).

.71 mm portion

The unexamined volume of the .71 mm portion measured 3.5 ml. I identified the four new taxa I observed in the first, third, and fifth consecutive subsamples. These are *Chrysothamnus* charcoal, *Juniperus osteosperma* scale leaves, and *Pinus edulis* needles, all traditionally associated with traditional ceremonial kiva activities and curing (Fewkes 1896; Hough 1897). The portion also contained monocotyledon stem pith. Other botanical remains consist of unknown gymnosperm wood, angiosperm wood with a lenticular surface morphology similar to that seen in *Chrysothamnus* and *Artemisia tridentata* (Appendix C), unknown diffuse-porous wood, a seed fragment, disseminules and bud. Both charred and uncharred insect parts, charred black spherical bodies, and uncharred bone fragments make up the nonbotanical/other content. Recovery is recorded in Table 9.17.

Table 9.17 Recovery of charred taxa by subsample number, firepit sample SC8 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
1	*Chrysothamnus*-type (cf)	rabbitbrush	charcoal	1
1	*Pinus edulis*-type	pinyon pine	needle fragment	3
2	*Pinus edulis*-type	pinyon pine	needle fragment	2
2	*Juniperus*-type	juniper	charcoal	>1
3	*Chrysothamnus*-type (cf)	rabbitbrush	charcoal	1
3	*Pinus edulis*-type	pinyon pine	needle fragment	3
3	*Juniperus*-type	juniper	charcoal	1
3	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
4	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
4	*Pinus*-type	pine	bark scale	3
5	Monocotyledon-type	monocotyledon	stem pith	1
5	*Pinus*-type	pine	bark scale	3
		.25 mm		
1	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
2	*Chrysothamnus*-type (cf)	rabbitbrush	charcoal	>1
2	*Pinus edulis*-type	pinyon pine	needle fragment	1
5	Monocotyledon-type	monocotyledon	stem pith	1
5	*Pinus edulis*-type	pinyon pine	needle fragment	1
6	*Pinus edulis*-type	pinyon pine	needle fragment	1
7	*Pinus edulis*-type	pinyon pine	needle fragment	1
8	*Pinus edulis*-type	pinyon pine	needle fragment	1
9	*Pinus*-type	pine	bark scale	1
10	*Pinus edulis*-type	pinyon pine	needle fragment	1
12	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
13	*Pinus edulis*-type	pinyon pine	needle fragment	1

.25 mm portion

The previously unexamined .25 mm portion originally measured 3.5 ml. I observed no new taxa but a quantity and variety of unknown botanicals and nonbotanical/other remains. Wood remains and tissues (epidermal, nodulose, and unknown) make up the bulk of the portion. There were seeds and buds in the sample I could not identify (Appendix C provides for descriptions regarding tissue types, photographs are presented in Appendix D). I recovered an uncharred purslane seed that may or may not be ancient (and thus not counted as “new” taxon). Based on the quantity of uncharred insect parts and uncharred seeds, these materials could represent seed rain vs. human use; not surprising for a midden deposit in an exposed trash accumulation (there is no evidence of collapsed roofing material in this midden). A minute sagebrush charcoal fragment displaying the cross-section pore patterning typical of that genus may also be present in the .25 mm portion. Identification is tentative. The outer bark morphology of *Chrysothamnus* differs from that of *Artemisia* because the surface lenticels contain nodules. The specimens in the .25 mm portion showed no evidence of this feature. New identifications offer additional information about the content of the midden.

Chrysothamnus charcoal. Rabbitbrush or rubber rabbitbrush (*Chrysothamnus nauseosus*-type found at Sand Canyon Pueblo today) was based on the wave-like patterning of internal pores on microscopic cross-section. No supporting evidence for either rabbitbrush or sagebrush (which also has a similar pore patterning with a difference: *Artemisia tridentata* is distinguished by a "flame" configuration versus the "wave" patterning of *Chrysothamnus*) was found when the larger portion sizes were re-examined. *Chrysothamnus* was used for a variety of purposes in the historic period.[110] As a kiva fuel, and historically dried for that purpose, the presence of *Chrysothamnus* wood charcoal may be the result of very specific ceremonial kiva related activities. *Chrysothamnus* charcoal is documented for the "*Cleome*" kiva, a space in the site-enclosing wall in block 200, kiva 1004, courtyard 1000 and kiva 1012, the dual-ventilation system kiva 1206 (similar to the D-shaped building kivas) and the courtyard surrounding it, midden 1214, and the D-shaped building. Most specimens were hand picked by excavators in macrofossil samples. Very little evidence of the plant (all charcoal) has been found in Sand Canyon Locality sites: Hedley Site Complex (two specimens), Lester's Site (one specimen), Lookout House (one specimen), Wood's Canyon Pueblo (15 specimens), Castle Rock Pueblo (33 specimens) with the stand-out collection at Yellow Jack Pueblo (approximately 100 specimens)(CCAC 2015a). The visibility of *Chrysothamnus* in roof deposits may be due to the drying of the wood on roofs, the use of the plant for tinder to burn roofs or the fracture patterns and burn times of the plant that due to its porosity may leave less obvious remains.

One of the qualities that make *Chrysothamnus* such a good fuel is that it thrives in disturbed coarse and well-drained soils in desert to semi-desert environments and spreads aggressively even when aggressive efforts are used to remove it. Burning of the lived plants only tends to make it dominant (Tilley and St. John 2012). The disturbed areas around SCP would provide excellent

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[110] A member of the Asteraceae family, many genera known to have pharmacological properties, rabbitbrush is documented as *Bigelovia howardii* (rabbitbrush) or Hopi *sivwapi* (yellow whip) by Fewkes (1896:20). The "dried plant" used as one of the four prescribed kiva fuels (20; Hough 1897). The plant has been associated with initiation ceremonies and used for yellow pigment (the flowers are infused and mixed with an undescribed chalky stone)(Fewkes 1896:20). Moerman (1998:160-161) records several ethnographic sources that confirm the Hopi use of the plant for windbreaks to protect young corn, the bark for basketry dye and prayer sticks (the green bark for green dye, yellow flowers for yellow dye). As a medicine, *Chrysothamnus* was recorded as a treatment for a variety of illnesses explored in chapter eleven.

conditions for the plant to grow prolifically and provide a reliable fuel source and windbreak. Its relative "absence" across the Sand Canyon site and the area, its apparent use in certain blocks and its special use in ceremony historically all combine to suggest that the plant was dried and kept close by for special use. As a tinder material to burn a roof, new plants would be less effective. As a specific kiva fuel, *Chrysothamnus* is historically associated with the northeast direction, the colour white, white corn, *Anogra runcinata* (white evening primrose) and aspen (Whiting 1939:45). *Siva'pi*, the Rabbtibrush clan or lineage of a clan of the Hopi Water-Corn Phratry, [111] is historically linked with *Zea mays* (*qa″*$_3$) and another important kiva-specific fuel, *te:'ve*, or *Sarcobatus vermiculatus* (greasewood)(47). Found in a great kiva midden, I estimate that rabbitbrush served as more than a simple fuel material but was contextually specific.

Pinus edulis needle fragments. I observed pinyon needle fragments in the unexamined residua of the smallest screens of this sample only. If needles were used routinely as tinder I would expect to see more evidence. The apparent absence of needles suggests a specialized activity in this location. Pinyon is noted for its cultural importance as a fire wood second only to juniper (Whiting 1939:3). Whiting makes a connection between fire, firewood, medicine and social organization in a "fire-juniper-pinyon" association of "ideas." The Pinyon clan (*Tuve″e*) and Juniper clan (*Ho'ko*, and *Kokof* [Kokof clan]) were part of the Fire-Coyote phratry (3, 47). In my analysis presented in chapter twelve, this fire-juniper-*Kookop* clan association has its roots in cosmological ordering in Pueblo religion. Ceremonial connections with pinyon needles as medicine is documented for Southwest groups (Moerman 1998:406). I suggest that pinyon needles present even in what appears to be disordered living in the great kiva circa A.D. 1270, provides evidence of continued ritual use of the space.

Combining data from the original and present analysis, SC8 contained eleven taxa: seven identified originally and four identified in the previously unexamined portions examined here. Using the new information, 64 per cent of the available taxonomic diversity was captured in the larger unsubsampled screen sizes. Thirty-six per cent of the richness of this sample was contained in the .71 mm screen and missed due to subsampling.

Sample SC9: *the smoldering trash midden* 1214

Sample SC9 (PD 357, FS 51) was collected from the midden in Block 1200 (1214), a deposit well characterized as a "smoldering" trash dump (CCAC 2004, Middens, Nonstructure 1214). The accumulation is the most abundant and diverse of all known accumulations at SCP. Block 1200 is also unique, distinguished by its transitions but apparent richness of plant remains noted for this

[111] Phratry: "a nameless division of kindred made up of two or more clans which have certain privileges, mainly ceremonial" (Titiev 1944:58 in Whiteley 1998:53).

midden and collections in one of its rooms (1205), described in chapter seven (pp. 215). Midden 1214 is direct evidence of new behaviour. The midden accumulated in spaces that were once a separate mealing room with a set of three metate bins and what is described as a “storage” room (CCAC 2004: Middens, Nonstructure 1214). Samples from the midden were also used in the evaluation of bulk sample FV14 in chapter eight (pp. 297-307). I estimate that the plant remains in this accumulation suggest that domestic and wild resources were available and discarded up until the time of the final warfare event. Data collected in the original analysis identifies fifteen taxa (Table 9.18).

Table 9.18 SC9 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	**Light fraction retained**	**Light fraction originally examined**	**No. of subsamples scanned (original data)**		**Original identified sample content**
			.71 mm	**.25 mm**	
1000 ml	137 ml	97 ml	9 (8.1 ml)	9 (2.7 ml)	*Juniperus* charcoal, *J. osteosperma* twigs *Pinus* (pine unspecified) charcoal and bark scales *Amelanchier/Peraphyllum* (serviceberry/peraphyllum) charcoal *Atriplex* (saltbush) charcoal *Fendlera* (Fendlerbush) charcoal *Prunus/Rosa* (Chokecherry/Rose) charcoal *Zea mays* (maize) cupule, kernel cheno-am (seeds) *Helianthus annuus* (common sunflower) achene Leguminosae (Legume/Pea family) seeds *Physalis longifolia* (common groundcherry) seedcoats *Portulaca retusa* (purslane) seed

The .71 mm portion was subsampled nine times (8.1 ml volume) accounting for two new taxa. The .25 mm portion was subsampled similarly with another two taxa recovered. I re-screened the remains and estimate that common groundcherry seeds and a legume/pea-type seed were found in the third and subsample of the .71 mm portion. Based on size, purslane or cheno-am seeds were probably recovered in the third and sixth subsamples of the .25 mm screen. On examination of the previously unexamined residua of this sample, I identified 16 additional new taxa. Data are recorded in Appendices G (Table G.9) and H (Table H.9). Accumulation curves are plotted in Figures H.9a and H.9b (Appendix H).

.71 mm portion

The unexamined volume of the .71 mm portion prior to subsampling measured 15 ml. I identified ten new taxa, many in the first few subsamples (see Figure G.9a, Appendix G). As in sample SC8, *Pinus edulis* needle fragments (photographs D.15 and D.16, Appendix D) were present. Wild resources consist of seeds and achenes of *Amaranthus* (pigweed), *Artemisia tridentata*, *Chenopodium*, *Eleocharis* (spikerush), *Nicotiana*, *Vaccaria* (*Vaccaria hispanica* (Mill.) Rauschert-type [cow soapwort]), Poaceae stem fragments (categorized as Poaceae “type B” and Poaceae type unknown) and grass seed (festucoid-type). Photographs D.18-21 (*Eleocharis*), D.30 and 31 (grass caryopses), D.38 to D.40 (Poaceae stem 'type B'), and D.51 to D.53 (*Vaccaria*) can be found in Appendix D. This portion also contained a variety of botanical materials that I could not identify. There are multiple fragments of an unknown angiosperm(s) with lenticular surface suggestive of *Artemisia* or *Chrysothamnus*. An additional gymnosperm wood charcoal in this portion did not fit the patterning of pine or juniper. I observed several unknown tissues (including "tissue type 5" inferred to be maize kernel epidermis) and a seed similar to madwort (*Alyssum*-like [madwort]) (photograph D.74).

Several taxa, particularly *Eleocharis*, *Nicotiana* and *Vaccaria*, are new to Sand Canyon Pueblo and the Sand Canyon Locality. Specimens like grass (and potentially rush/spikerush) stem fragments are identifiable to genus or species (see Appendix C). The final new taxon, an *Artemisia tridentata* achene, is ethnographically significant resource and a season-of-use indicator. The presence of a seed cache of *Artemisia* achenes in kiva 102 and the pharmacological activity of sagebrush hints that these specimens were used for medicinal purposes.

.25 mm portion

The unexamined volume of light fraction for this portion measured 21.0 ml. Six new taxa were identified and recovered in the first, fourth, sixteenth, eighteenth, twenty-second and fifty-second subsamples. I infer wild food and fuel types for the identifications which include *Ceratoides lanata* (winterfat), grass and rush-type stem fragments including three types based on morphological characteristics: Poaceae "type A," "type D," and stem "type E"/*Juncus?* (photographs D.24 and D.25, respectively, Appendix D. Descriptions are provided in Appendix C. A *Polanisia* (clammy-weed) seedcoat, monocotyledon leaves and unknown fibrovascular bundles were also present. The minute and fragmentary nature of this portion size is reflected in the degree of diversity of unknown but morphologically distinctive charred materials including tissue types (described as nodulose, type 5, unknown, vitrified), charred degraded seeds, and insect parts and pellets. Uncharred materials consist of unknown disseminules, bone, tissue, and additional insect parts and pellets. Of the 68 subsamples that make up the volume of this screen, the final new taxon was recovered in the fifty-second subsample. An unmanageable volume in terms of time for analysis, this portion also held significant variety of cultural materials. One of the unique features of sample SC9 is the abundance of fractured and fragmented turquoise rock, not noted for any other sample or deposit. New plant data identified in sample SC9 not previously discussed in this chapter are itemized here:

Ceratoides lanata twig. More recently categorized as *Krascheninnikovia lanata* (Pursh) A. Meeuse & Smit, winterfat is a genus of the Chenopodiaceae family and native to the area (USDA NRS 2015). Well documented as an ethnomedicine for fever, various Native American groups used the root (powdered) and leaves as a drug for eye medicine, as burn dressings, for sore muscles and as a head and scalp tonic (Moerman 1998:293). The plant was used historically in ceremony to produce steam (293; Colton 1974). Whiting (1939:32) records the Hopi use of the plant (as *Eurotia lanata* (Pursh) Moq.) as an ingredient in fever medicine (74). The use of the root, the grinding of roots and the use of leaves would leave little archaeological evidence. Identified only in a macrofossil sample collected from a midden at Wood's Canyon Pueblo, only three specimens are documented for the Sand Canyon Locality (CACC 2015), none previously for Sand Canyon Pueblo.

<u>*Eleocharis*-type seeds and achenes</u>. A new genera for Sand Canyon, Bohrer and Adams (2006a [1979]:755) noted a single achene of *Eleocharis montanus* (mountain spikerush) at Salmon Ruins from the Chacoan occupation of the site circa A.D. 1090-1130 inferred to represent use of the plant as food although not confirmed as ingested in coprolite analysis at Salmon Ruins (Reinhard et al. 2006:888). Adams (1988) also records *Eleocharis palustris* for Lovelock Cave in Nevada (B.C. 1000-A.D. 1000) where the plant was used for matting, some of the material bound with *Juncus* (216). Coprolite evidence confirms that achenes of *Eleocharis* cf. *utahensis* were eaten at Lovelock Cave around A.D. 740 (216; Heizer and Napton 1969:567). A known ethnomedicine (*Eleocharis dulcis*, commonly known as Chinese water chestnut), was used by medical practitioners and healers to treat sores, wound infections, gastrointestinal disease, respiratory and urinary tract infections (Zhan et al. 2014:794). Recent findings demonstrated that extracts from *E. dulcis* act on food-associated bacteria and may serve to prevent deterioration of stored foods (796). A native Colorado species is *Eleocharis palustris* (L.) Roem. & Schult. (common spikerush). Little ethnobotanical information for this particular species is documented for Southwestern groups, but others such as the Seminoles used the plant as an analgesic, antidiarrheal, antirheumatic and febrifuge (Moerman 1998:208). *Eleocharis rostellata* (Torr.) Torr., or beaked spikerush, is a Ramah Navajo ceremonial medicine and emetic (208). The leaves and stems are tiny and the seeds and achenes may be evidence of the use of the roots for medicinal properties. *Eleocharis* is found in moist environments, the achenes ripen in the fall (Adams 1988:216). Based on evidence of this taxon alone, additional subsampling would have been of value. The size of seeds and achenes almost assure sorting into .25 mm light fraction screens and under-estimation of the plant would result as it has in this sample.

<u>*Polanisia* seedcoat</u>. A member of the Capparaceae family (Caper), *Polanisia* Raf. (clammyweed) and local Colorado *Polanisia dodecandra* (L.) DC. (redwhisker clammyweed) are more recently classified as subfamily Cleomaceae (Heil and O'Kane 2005:33; Inda et al. 2008) and Cleomoideae/Cleomaceae (Inda et al. 2008). *Polanisia* is considered a related group of *Cleome* based on morphological traits (114; Judd et al. 1994). *Polanisia* may also share phytochemical and pharmacological attributes with this medicinal and seemingly potent metaphorical plant (further explored in chapter eleven). *Polanisia trachysperma* plays a role, too in ceremony associated with the Cactus fraternity (Stevenson 1915:96). *Polanisia* has not been identified at Sand Canyon Pueblo or in the Sand Canyon Locality (CCAC 2015a) although Capparaceae seeds (unidentified to genus or

species) have been: three specimens at Lester's site, two specimens at Lillian's site, one specimen at the elaborate Troy's Tower.

Stems (Poaceae/Rush). An abundance of stems of differing surface and internal features sorted more abundantly into the .25 mm screen. Identified as types A, B, C, D and E, these are described in Appendix C. "Type E" is a rush/sedge species (Cyperaceae) based on its internal characteristics and may be the stems of *Eleocharis*. Certainly the stems of rush (*Juncus balticus* Willd. specifically) were ceremonially significant in the connection with water to the Hopi (Whiting 1939:70).

"The turquoise rock." In excess of 15,000 fragments of rounded and angular turquoise-coloured mineral grains concentrated in the .25 mm screen. These represent a new material not documented for other flotation samples at SCP or for any other site excavated by CCAC to date. The research staff of the University of British Columbia Earth and Ocean Sciences Department in Vancouver, B.C., analyzed a small sample of approximately 100 pieces for me. They identified the material as Ferrian illite/Glauconite, an iron-bearing mineral that occurs in ancient water-reducing environments (the underwater environment that was originally the Colorado Plateau). The grains were assessed by Dr. John Greenhough, as both water-rounded and purposely broken materials (personal communication, September 2009; also confirmed by Dr. Mati Raudsepp, UBC Earth and Ocean Sciences, personal communication, October 2009). The occurrence of this "turquoise" or "green rock" has been noticed at other CCAC archaeological sites (Steve Copeland, personal communication, June 2009). The grains increase in quantity throughout the sample, only decreasing slightly in the last few subsamples (photographs D.151 to D.153). Turquoise stones (sometimes predominately blue, other times green) are mythologized in historical records by the Zuni and Hopi (Parsons 1996 [1939]:177). When supernatural "pairs" consist of male and female, the male is associated with the colour turquoise (blue-green although sometimes called green, sometimes called blue), the female associated with yellow (102). Parsons (1996 [1939]:selections from 218, 219, 225) reiterates a Zuni Emergence narrative linking the first appearance of the people from the underworld with several key features: turquoise, the War Twins ("*Ahayuta*"), corn meal, rabbit sticks, and Bear. A parsed version of this narrative is presented in chapter eleven. Stevenson (1915:36) writes that, "vegetation is symbolized by [the colour] blue-green on the sacred dance-kilts worn by the personators of the rain-makers." The value of water and seed are acted out in ceremony through the creation and use of representational fetishes and the naming of all things as interconnected with the world around them.[112] A bird mosaic inlaid with turquoise on its back (the features made with inlaid

[112] A single authentic turquoise bead was recovered at SCP from the plaza (nonstructure 1500) outside the west kiva (1502). Pueblo Bonito and other sites in Chaco Canyon are noted for jewelry and decoration (Cordell

strips of the stone) "recalling designs of ancient pottery" was found near Cortez marking the importance of turquoise and effigies in Ancestral Puebloan sites (Pogue 1912:458). Turquoise "matrix" was also used historically in jewelry, masks, ornaments, and offerings (461). Powdered turquoise is recorded for Navajo ceremonies (464). Ground green or blue-green stones may be proxies for similar purposes. Mathien (2001:111) records the practice of turquoise chip offerings in the construction and remodeling of great kivas in Chaco Canyon. If these specimens are unique to block 1200, the evidence singles out this block, similar to blocks 100, 1000 and the D-shaped building as suggestive of a particular group and ownership of culturally important metaphoric content.

<u>*Vaccaria*</u>. A member of the Caryophyllaceae (Pink) family, *Vaccaria hispanica* (Mill.) Rauschert or cow soapwort, is classified as an introduced plant from Eurasia (USDS NCRS 2015). Also known as *Saponaria vaccaria* L., the plant grows in fields and disturbed areas, flowering in the spring and summer, and noted to be increasingly rare or extirpated. Its presence in Colorado may represent historical rather than contemporary distribution (e-floras 2015). Heil and O'Kane (2005:31) record *Vaccaria pyramidata* Med., a synonym of *V. hispanica,* in Archuleta County, Colorado, that borders northern New Mexico. *Vaccaria* seeds contain saponin and are poisonous to cattle if ingested (e-Floras 2015). I could find no record of ethnobotanical use but recent phytochemical analysis suggests that the saponin content (specifically triterpene disdesmosidic saponins) when used in low concentrations can be pharmacologically active.[113] The presence of the seed in an indoor refuse layer protected by additional layers of debris suggest archaeological evidence. The distribution of the plant as a Eurasian import in the area is unknown. Cattle ranching and disturbance is also a plausible explanation for contamination in the historic period. Table 9.19 records the order of observations (over).

1996:229), beginning in Basketmaker III (ca. A.D. 500)(Mathien 2001). Turquoise use in historic context includes decoration of prayer-sticks and as katsina "food offerings" (Parsons 1996 [1939]:299-300). It is also used as funerary offerings in other contexts, "a bead necklace is hung temporarily around the neck of a laidout deer" and "offered to the War gods before going to war" at Zuni Pueblo (299-300). Pogue (1912:452) records that when the Spanish arrived east of the Yaqui River in Sonora in 1535 they were told that turquoise was acquired through exchange with northern groups for parrot feathers. Coronado also learned in 1540 that turquoise was offered in religious ceremonies associated with water (454).

[113] Ramirez-Erosa (2008) notes anti-cancer/anti-tumour activity in low doses for *Vaccaria*. Used in traditional Chinese medicine for more than a thousand years, the seeds have been a treatment for amenorrhoea, infections, to stop bleeding, as an analgesic and used to treat benign prostatic hyperplasia (Qi et al. 2013).

Table 9.19 Recovery of charred taxa by subsample number, midden sample SC9 (new taxa shaded).

Subsample	Taxon	Common name	Part	No. of specimens
		.71 mm		
1	*Pinus edulis*-type	pinyon pine	needle fragment	1
3	*Amaranthus*-type	pigweed	seed	1
3	*Eleocharis*-type	spikerush	achene	1
4	*Chenopodium*-type	goosefoot	seed	2
4	*Juniperus osteosperma*-type	Utah juniper	scale leaf	>1
4	Poaceae (unknown type)	grass	stem fragment	1
4	*Physalis longifolia*-type	common groundcherry	seedcoat	1
4	*Eleocharis*-type	spikerush	achene	1
5	*Pinus edulis*-type	pinyon pine	needle fragment	1
5	*Nicotiana*-type	tobacco	seedcoat	1
5	*Portulaca retusa*-type	purslane	seed	1
5	*Eleocharis*-type	spikerush	seed	1
5	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
7	*Amaranthus*-type	pigweed	seed	1
7	Poaceae (type B)	grass	stem fragment	1
7	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
7	*Vaccaria*-type	soapwort	seedcoat	1
8	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
10	Poaceae (type B)	grass	stem fragment	1
10	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
10	*Physalis longifolia*-type	common groundcherry	seed	1
11	Poaceae (type B)	grass	stem fragment	1
11	*Physalis longifolia*-type	common groundcherry	seed	1
12	Poaceae (type B)	grass	stem fragment	2
12	*Juniperus osteosperma*-type	Utah juniper	scale leaf	3
12	*Physalis longifolia*-type	common groundcherry	seed	1
13	Poaceae (type B)	grass	stem fragment	3
13	*Physalis longifolia*-type	common groundcherry	seed	1
13	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
15	Poaceae (unknown type)	grass	stem fragment	1
15	*Eleocharis*-type	spikerush	achene	1
16	Poaceae (festucoid-type)	festucoid grass	caryopsis	1
16	*Juniperus osteosperma*-type	Utah juniper	scale leaf	2
16	*Portulaca retusa*-type	purslane	seed	1
17	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
18	Poaceae (type B)	grass	stem fragment	4
18	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
18	*Eleocharis*-type	spikerush	achene	1
18	*Artemisia tridentata*-type	big sagebrush	achene	1
19	Poaceae (type B)	grass	stem fragment	2
19	*Pinus edulis*-type	pinyon pine	needle fragment	1
		.25 mm		
1	Poaceae-type (type A)	grass	stem fragment	>3
1	*Physalis longifolia*-type	common groundcherry	seedcoat	1
2	Poaceae-type (type A)	grass	stem fragment	1
2	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
3	*Eleocharis*-type	spikerush	seed	2
4	Poaceae-type (type D)	grass	stem segment	1
4	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
4	*Pinus edulis*-type	pinyon pine	needle fragment	1
6	*Eleocharis*-type	spikerush	achene	1
6	*Eleocharis*-type	spikerush	seed	2
7	*Amaranthus*-type	pigweed	seed	1

continued…

Table 9.19 Recovery of charred taxa by subsample number, midden sample SC9 (new taxa shaded), continued.

Subsample	Taxon	Common name	Part	No. of specimens
		.25 mm continued		
7	Poaceae (type D)	grass	stem segment	4
7	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
7	*Eleocharis*-type	spikerush	seed	2
8	*Amaranthus*-type	pigweed	seed	1
8	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
8	*Portulaca retusa*-type	purslane	seed	1
8	*Eleocharis*-type	spikerush	achene (half)	1
9	Poaceae (unknown type)	grass	stem segment	3
9	*Portulaca retusa*-type	purslane	seed	1
9	*Eleocharis*-type	spikerush	achene	1
9	*Eleocharis*-type	spikerush	seed	2
10	Poaceae (type A)	grass	stem segment	1
10	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
10	*Eleocharis*-type	spikerush	achene	1
11	Poaceae (unknown type)	grass	stem fragment	5
12	Poaceae (unknown type)	grass	stem segment	4
12	*Eleocharis*-type	spikerush	seed	1
13	Poaceae (unknown type)	grass	stem segment	1
13	*Eleocharis*-type	spikerush	seed	1
13	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
15	*Eleocharis*-type	spikerush	seed	2
16	Poaceae (type D)	grass	stem segment	3
16	Monocotyledon-type	monocot, unknown	fvb[a]	1
16	*Eleocharis*-type	spikerush	seed	1
17	Poaceae (type D)	grass	stem segment	1
18	Cyperaceae-type	rush or sedge	stem segment	1
19	Cyperaceae-type	rush or sedge	stem segment	3
19	*Portulaca retusa*-type	purslane	seed	1
20	*Pinus edulis*-type	pinyon pine	needle fragment	1
20	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
20	Monocotyledon-type	monocot. Unknown	fvb	2
20	*Portulaca retusa*-type	purslane	seed fragment	1
20	*Eleocharis*-type	spikerush	achene	1
21	Cheno-am	goosefoot	seed	1
21	Poaceae (unknown type)	grass	stem fragment	5
21	Monocotyledon-type	monocot. Unknown	fvb	1
22	*Polanisia*-type	clammy-weed	seedcoat	1
22	Poaceae (unknown type)	grass	stem fragment	7
23	Cyperaceae-type	rush or sedge	stem segment	2
23	*Eleocharis*-type	spikerush	achene	1
24	Poaceae (unknown type)	grass	stem fragment	1
24	*Juniperus osteosperma*-type	Utah juniper	twig	1
24	Monocotyledon-type	monocot. Unknown	leaf fragment	1
25	*Juniperus osteosperma*-type	Utah juniper	twig	1
25	Monocotyledon-type	monocot. Unknown	leaf fragment	1
25	Poaceae (type A)	grass	stem segment	1
26	Poaceae (unknown type)	grass	stem fragment	>1
27	Poaceae (type B)	grass	stem segment	>1
28	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
28	*Eleocharis*-type	spikerush	achene	1
28	*Eleocharis*-type	spikerush	seed	1
29	Poaceae (type B)	grass	stem segment	2

continued...

Table 9.19 Recovery of charred taxa by subsample number, midden sample SC9 (new taxa shaded), continued.

Subsample	Taxon	Common name	Part	No. of specimens
		.25 mm continued		
29	*Eleocharis*-type	spikerush	achene	1
29	*Eleocharis*-type	spikerush	seed	1
30	Poaceae (type B)	grass	stem segment	2
30	*Eleocharis*-type	spikerush	seed	1
31	Poaceae (unknown type)	grass	stem fragment	1
31	*Eleocharis*-type	spikerush	achene	1
32	*Pinus edulis*-type	pinyon pine	needle fragment	3
32	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
34	Poaceae (unknown type)	grass	stem fragment	1
34	Monocotyledon-type	monocot. Unknown	leaf with fvb	2
35	Moncotoyledon-type	monocot. Unknown	leaf with fvb	1
36	Poaceae (type D)	grass	stem segment	1
36	Poaceae (type A)	grass	stem segment	1
36	Monocotyledon-type	monocot. Unknown	leaf with fvb	1
36	Cheno-am	goosefoot	seed	1
37	Poaceae (type D)	grass	stem segment	2
37	Poaceae (unknown type)	grass	stem fragment	1
37	*Eleocharis*-type	spikerush	achene	1
38	Poaceae (unknown type)	grass	stem fragment	2
38	*Eleocharis*-type	spikerush	achene fragment	1
39	Poaceae (unknown type)	grass	stem fragment	1
40	Monocotyledon-type	monocot. Unknown	fvb	1
41	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
41	Monocotyledon-type	monocot. Unknown	fvb	1
42	Cheno-am	goosefoot	immature seed interior	2
43	Cyperaceae-type	rush or sedge	stem segment	1
44	*Eleocharis*-type	spikerush	seed	1
45	*Eleocharis*-type	spikerush	achene	1
46	Monocotyledon-type	monocot. Unknown	fvb	1
48	Cheno-am	goosefoot	seed	1
48	Poaceae (unknown type)	grass	stem fragment	1
48	*Pinus edulis*-type	pinyon pine	needle fragment	1
49	*Pinus edulis*-type	pinyon pine	needle fragment	2
50	*Pinus edulis*-type	pinyon pine	needle fragment	3
52	*Ceratoides lanata*-type (cf)	winterfat	twig fragment	1
52	Cyperaceae-type	rush or sedge	stem segment	1
54	*Eleocharis*-type	spikerush	seed	1
56	*Portulaca retusa*-type	purslane	seed	1
57	Poaceae (unknown type)	grass	stem fragment	1
58	Cyperaceae-type	rush or sedge	stem segment	1
58	*Amaranthus*-type	pigweed	seed	1
61	Cyperaceae-type	rush or sedge	stem segment	1
62	Cyperaceae-type	rush or sedge	stem segment	2
63	Poaceae (unknown type)	grass	stem fragment	1
63	Monocotyledon-type	monocot. unknown	leaf with fvb	1
67	Monocotyledon-type	monocot. unknown	fvb	1
67	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1

Notes:
[a] Fibrovascular bundle.

SC9 produced unusual plant and nonbotanical remains in its smallest light fraction screens that were missed due to subsampling. These taxa enhance the interpretation of midden 1214 and suggest that although the use of block 1200 shifted later in the occupation, the residents or users of the block were engaged in a variety of activities that suggest abundant food resources, possible ritual and medicinal discard. When combined with an additional sample evaluated in chapter seven (FV14), it seems clear that people were occupied in a variety of activities not limited only to food procurement and effects of drought. Similar to use in the D-shaped building where the kiva shares architectural similarity in its dual ventilation systems, block 1200 may have held an important leadership, religious or ritual role, once connected to the building. The ground and fragmented "green" rock suggests something unusual. It is also possible that these minute specimens have been observed but not considered in the analysis of other samples, making a case for the importance of flotation samples as repositories for evidence of processing and other artifacts.

When all taxa are combined, SC9 contained at least 31 recoverable taxa: 15 were observed in the original analysis and 16 additional new taxa were identified in the previously unexamined portions of the smallest screens suggesting that only 35 per cent of the taxonomic richness of SC9 was available in the larger unsubsampled portion sizes. The remaining 65 per cent sorted into the smallest screens, the bulk of that in the .71 mm portion. The SAC flexible minimal volume did not respond to the diversity of the sample Additional subsampling clearly enhances the interpretation of this midden. Accumulation plots for both the .71 and .25 mm screen illustrate the patterning of observations for all types of documented remains.

Sample SC10: Pre-A.D. 1252 courtyard refuse midden 513

Sample SC10 (PD 715, FS 5) was recovered from secondary refuse located below the kiva courtyard in block 500. The accumulation pre-dates construction of the courtyard, estimated around A.D. 1252 (CCAC 2004: Extramural Surfaces, Nonstructure 513). Consisting of a layer of gray ash and organic material, it was not designated as a formal midden. The sample likely reflects the "earliest" time period of occupation, which I suggest reflects the A.D. 1240s and initial construction of the pueblo (CCAC 2004: Extramural Surfaces, Nonstructure 513). I distinguish the block by its subterranean kiva and *tchamahia*, the Hopi "rain knife" of Parsons' (1996 [1939]:211) ethnography (see chapter seven, pp. 196-197 for excavation details). The ancestral architectural style of a subterranean kiva and room, the artistic decoration of the kiva using a variety of colour pigments, the separate mealing room, *tchamahias* and rare stone mortar all combine to provide evidence of an "ancestral," or traditional focus in this location. No obvious changes are evident, the mealing room indicates to me continued production of maize flour (Table 9.20).

Table 9.20 SC410 sample data based on previous analysis (CCAC 2015a).

Pre-flotation volume	Light fraction retained	Light fraction originally examined	No. of subsamples scanned (original data)		Original identified sample content
			.71 mm	.25 mm	
1000 ml	58 ml	45 ml	3 (2.7 ml)	4 (1.2 ml)	*Juniperus* charcoal *Pinus* (pine unspecified) charcoal *Prunus/Rosa* (chokecherry/rose) charcoal *Phaseolus vulgaris* (common bean) *Zea mays* (kernel, kernel fragments, embryos, cupules) *Stipa/Oryzopsis hymenoides* (Indian ricegrass) unknown organic material

Four consecutive subsamples (1.2 ml) were examined in the .25 mm portion suggesting that one new taxon was recovered in the first subsample in this screen. The recovered materials were re-screened and confirm that the Indian ricegrass floret fragment could have been recovered in this portion. I identified five new taxa. Data are recorded in Appendices G (Table G.10) and H (Table H.10). Accumulation curves are plotted in Figures H.10a and H.10b (Appendix H).

.71 mm portion

The unexamined volume measured 7.9 ml. I observed four new taxa in my first, second, and ninth consecutive subsamples. These include *Artemisia tridentata* charcoal, *Amaranthus* and *Portulaca retusa* seeds and "Sand Canyon *Malva*-type" fruit previously recovered in sample SC2. In addition to the taxa identified in this portion, distinct botanical and nonbotanical/other-type materials were present consisting of a small amount of unknown tissue "type 5" (inferred kernel epidermis fragments), unknown wood charcoal, a bud, uncharred disseminules, insect parts and fecal pellets. Of these, fecal pellets from termites indicate infestation and the possible use of old wood. Big sagebrush charcoal in this screen could be the result of its burn and fracture patterns and may be routinely missed in the analysis of the smallest screens due to wood subsampling in the 4.75 mm and 2.8 mm portions.

.25 mm portion

The unexamined volume measured 4.6 ml. I found *Juniperus osteosperma* scale leaves in the second subsample. Unknown botanical remains continue to accumulate until the eighth subsample. *Pinus* bark scales and *Portulaca retusa* seeds present in the .71 mm portion were also scattered throughout this portion. The smallest light fraction screen produced a relative abundance of ten specimens of purslane providing clear evidence that subsampling underrepresents purslane. I observed distinctive botanical remains consisting of unknown tissues (nodulose-type and "type 5"), an unknown seed fragment and two buds. Distinctive nonbotanical/other-type remains continue to accumulate throughout. Charred termite evidence is also present in this portion size. Observations of new taxa are recorded on Table 9.21.

Table 9.21 Recovery of charred taxa by subsample number, sample SC10 (new taxa shaded).

Subsample	Taxon	Common name	Part (charred)	No. of specimens
		.71 mm		
1	*Artemisia tridentata*-type (cf)	big sagebrush	charcoal	1
1	*Pinus*-type	pine	bark scale	2
1	*Portulaca retusa*-type	purslane	seed	2
2	Sand Canyon *Malva*-type	mallow-type	fruit schizocarp	1
2	*Pinus*-type	pine	bark scale	>2
3	*Zea mays*	maize/corn	cupule	1
3	*Pinus*-type	pine	bark scale	>1
4	*Artemisia tridentata*-type	big sagebrush	charcoal	1
4	*Pinus*-type	pine	bark scale	>1
5	*Pinus*-type	pine	bark scale	>1
6	*Pinus*-type	pine	bark scale	>1
7	*Pinus*-type	pine	bark scale	>1
9	*Amaranthus*-type	pigweed	seed	1
9	*Pinus*-type	pine	bark scale	>1
10	*Pinus*-type	pine	bark scale	>1
		.25 mm		
1	*Portulaca retusa*-type	purslane	seedcoat	1
2	*Amaranthus*-type	pigweed	seed	1
2	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
2	*Pinus*-type	pine	bark scale	>2
3	*Pinus*-type	pine	bark scale	>1
3	*Portulaca retusa*-type	purslane	seed	1
4	*Pinus*-type	pine	bark scale	>1
5	*Pinus*-type	pine	bark scale	>1
5	*Portulaca retusa*-type	purslane	seed	1
6	*Pinus*-type	pine	bark scale	>1
6	*Portulaca retusa*-type	purslane	seed	1
7	*Juniperus osteosperma*-type	Utah juniper	scale leaf	1
7	*Pinus*-type	pine	bark scale	>1
7	*Portulaca retusa*-type	purslane	seedcoat	1
8	*Portulaca retusa*-type	purslane	seed	1
8	*Pinus*-type	pine	bark scale	>1
9	*Portulaca retusa*-type	purslane	seedcoat	1
10	*Pinus*-type	pine	bark scale	>1
11	*Portulaca retusa*-type	purslane	seed	2
13	*Pinus*-type	pine	bark scale	>1
13	*Portulaca retusa*-type	purslane	seed	1

The SAC flexible minimal volume did not respond to the richness of the sample. Additional subsampling enhances the interpretative potential of this early occupation midden providing evidence of wild plants similar to that of later and "latest" deposits. The use of shrubs for fuel wood and the presence of a variety of wild seeds have been associated with an increase in wild seed use in late-latest occupation contexts (A.D. 1270s) as evidence of an adaptive strategy in response to harsh drought conditions, potential environmental degradation and plausible dietary stress (Adams et al. 2007; Kuckelman 2007b). The findings from this sample provide data to support a continuance of wild plant procurement consistent with the core dietary structure of Ancestral Pueblo. Milled maize, common bean, and a variety of wild plant evidence in the context of the final attack that confirms similar evidence noted for the earliest known occupation. The screening and subsampling of the smallest particle-sized portions imposes constraints on evidence of processed maize and wild plant seeds.

Charred "Sand Canyon *Malva*" immature fruits in this sample indicates that likely the leaves, stems and roots were used pre-A.D. 1252 in block 500 as well as in a catastrophic context in the three-firepit room (1002) near the tower in block 1000 (SC2). When the data are combined, sample SC9 contained a minimum of twelve recoverable and identifiable taxa. Forty-two per cent of the taxonomic diversity based on this data accumulated in the unexamined portions of the .71 and .25 mm screens. Of these, 67 per cent was to be found in the .71 mm portion.

Discussion

Ten out of ten samples used to assess the effects of SAC subsampling produced additional data and enhanced the interpretative potential of most deposits from which they were collected. Three samples were deposited early in the occupation and provide an opportunity to re-evaluate inferences of subsistence over time. Small wild seeds and fragments are underestimated. New identifications, such as "tissue type 5" provide evidence of milled maize (kernel epidermis), a cuisine that is seasonally specific to pre-harvest of maize crops (Sutton and Reinhard 1995). Five samples evaluated here indicate a milled maize cuisine based on evidence of crushed kernels or "tissue type 5." These were found in contexts at the beginning of the occupation until its catastrophic end. Other new information includes additional wood types not found in the larger screens. Wood species that are highly porous may be missed due to their fracture and burn patterns and the reliance on the largest light fraction screens for charcoal samples. This effect applies specifically to *Artemisia tridentata* with its flame/flare pattern of internal pores and fragile ring boundaries and the densely ringed wave pore patterning of *Chrysothamnus*. The first clue for the presence of these shrubs is remains of the lenticular surface of the wood. As noted in Appendix C, the surface of *Artemisia* differs from *Chrysothamnus* which is characterized by embedded and obvious strings of nodules not present in *Artemisia tridentata* (photographs D.145-D.150, Appendix D). These taxa were used as fuels in hearths and firepits in the historic period and dried on roofs. These conveniently located "roof" shrubs would provide easily used materials for heating, light, and cooking and would be part of a burn assemblage when roofs were set alight after the village was depopulated. Thus, shrub evidence in roof fall may be a deliberate drying and storage strategy for fuel, not necessarily placement of tinder material for the deliberate burning of roofs. The continued use of juniper, pine and rose-species woods from early to latest occupation tells us that the combination of juniper-pine-rose was a consistent fuel preference throughout the occupation, hinting that these sources were still available ca. A.D. 1277.

Four trash samples with termite fecal pellets provide the evidence to suggest that later construction beam dates reflect repair due to infestation. Termite evidence was observed in courtyard 513 ca. A.D. 1240s, trash in midden 515 ca. A.D. 1250s, midden 1214 ca. A.D. 1270s and in trash from the great kiva midden ca. A.D. 1277. Chapter eight bulk volume samples provide similar evidence: additional samples (subsampled) from the great kiva midden (sample FV13), an additional sample from midden 1214 (FV14), and trash from bi-wall room 1513 in the D-shaped building all contain termite evidence. It has been suggested that the presence of termite fecal pellets in firepits, hearths, burned spots, and refuse accumulations were the result of burning termite infested wood (Adams et al. 2007). The presence of juniper and pine wood in fires at SCP occurs throughout the occupation. Construction continued using large wood beams until the mid A.D. 1270s, which would require large trees within a reasonable distance. Adams (1984) study and identification of termite fecal pellets has provided the evidence to support early dates for SCP. Additional taxa grouped by temporal context and diet/cuisine, known ethnomedicine, and religious/ritual categories based on ethnographic sources and contemporary pharmacological studies are presented in Table 9.22 (p. 379).

By scanning the total light fraction content of the .71 mm and .25 mm portions, taxonomic richness of these ten samples increased by 31 per cent (Figure 9.1).

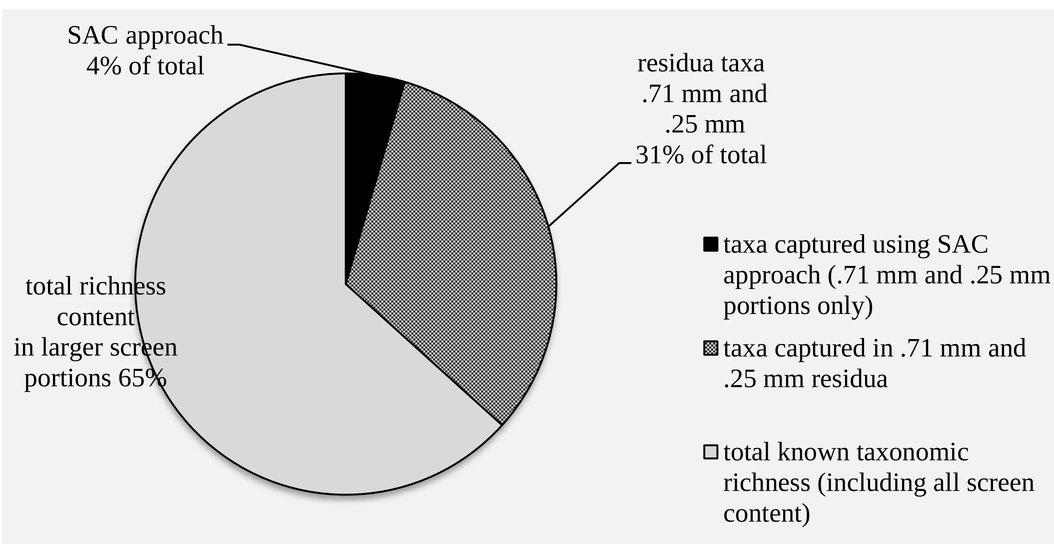
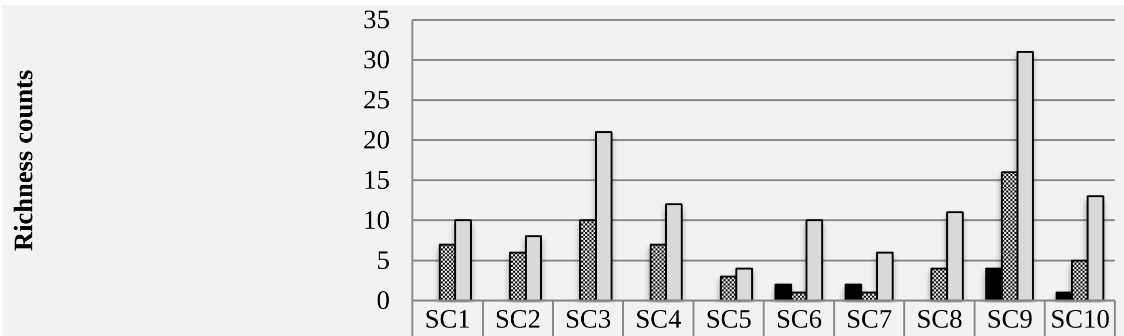


Figure 9.1 Smallest light fraction screen content, ten Sand Canyon Pueblo samples (.71 mm and .25 mm screens, charred plant remains only).

Table 9.22 New taxa identified in previously subsampled .71 and .25 mm portions by estimated temporal context (†termite evidence present).

Sample	Feature	Unit	Estimated timing	Descriptive phase	Diet/cuisine	Known ethnomedicine	Religious/ritual
SC10†	trash	courtyard 513	ca. A.D. 1240s	initial occupation	milled maize? pigweed purslane Sand Canyon *Malva*-type	pigweed Sand Canyon *Malva*-type Utah juniper	big sagebrush juniper
SC7†	trash	midden 515	ca. A.D. 1250s	early ideological	purslane		
SC6	trash	midden 109	ca. A.D. 1250s or 1270s?	early ideological or transitional?	festucoid grass	Utah juniper	juniper
SC1	firepit	courtyard 1000	early 1260s?	ideologically expansive	milled maize? big sagebrush purslane panicoid grass	big sagebrush Utah juniper	juniper
SC3	firepit	D-shaped building bi-wall room 1527	ca. A.D. 1260s	ideologically expansive	milled maize cheno-am brome grass other grass purslane	big sagebrush cheno-am	big sagebrush? oak
SC9†	trash	midden 1214	ca. A.D. 1270s	transitional	milled maize? big sagebrush clammyweed festucoid grass goosefoot, pigweed rush/sedge/spikerush soapwort	big sagebrush clammyweed goosefoot pigweed pinyon pine rush/sedge/spikerush soapwort	rush/sedge/spikerush wild tobacco winterfat pigweed pinyon pine
SC8†	trash	great kiva midden 803	ca. A.D. 1270s	late transitional/ca. A.D. 1277		pinyon pine Utah juniper	rabbitbrush pinyon pine juniper
SC4	hearth	kiva 102	ca. A.D. 1277	catastrophic	groundcherry purslane cheno-am	big sagebrush wild tobacco cheno-am Utah juniper	big sagebrush juniper wild tobacco
SC2	firepit	room 1002	ca. A.D. 1277	catastrophic	milled maize? pigweed purslane	pigweed Sand Canyon *Malva*-type	pigweed
SC5	hearth	kiva 600	ca. A.D. 1277?	catastrophic?	cheno-am	cheno-am	juniper

I counted 126 unique taxa by combining original data and new information for the ten samples evaluated. The SAC approach originally accounted for four per cent of the taxonomic potential when relying on the SAC standardized flexible minimal volume. Complete analysis of the remaining residue yielded a 31 per cent increase or an additional 60 new taxa in the previously unexamined .71 mm and .25 mm portions. Individual sample data show a significant underestimation of taxonomic content when using the SAC approach standards (Figure 9.2).



	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10
■ taxonomic richness counts using SAC subsampling .71 mm and .25 mm portions only)	0	0	0	0	0	2	2	0	4	1
▩ new taxa identified in previously unexamined .71 mm and .25 mm residua	7	6	10	7	3	1	1	4	16	5
□ total known taxonomic richness (all data)	10	8	21	12	4	10	6	11	31	13

Figure 9.2 Total known plant taxa and SAC approach results for ten Sand Canyon Pueblo samples. Number of taxa (charred plant remains) identified comparing SAC subsampling and new taxonomic content identified on complete analysis of .71 and .25 mm screen portions.

Figure 9.2 also indicates a “diversity” effect. In the case of sample SC9, even the diversity (variety and abundance of specimens) of the smoldering trash midden (1214) was ineffective to propel additional sampling. The accumulation curves (Appendix H) show that new material is observed throughout the scanning process for all categories of remains (taxa, botanical, and nonbotanical) and clearly indicates that redundancy of sampling effort is not achievable by subsampling. The approach relies on redundancy/asymptote in a particular pattern—common remains in the initial subsampling phases tapering off to rare taxa as subsampling proceeds. In ten samples there was not a sharp rise in the quantity of observations of new taxa and new taxa do not necessarily become less common or “rare.” The distribution is unpredictable and a reliance on patterning of observations will not provide the information needed to continue or curtail subsampling.

The .71 mm screen is the most productive for new information in these ten samples. A synthesis of the results of this chapter and chapter seven and implications are further study explored in chapter ten.

Chapter summary

The most problematic in terms of sampling time and effort, the .71 mm and .25 mm light fraction portions of flotation samples contain plant data that are missed through subsampling. The order of occurrences of identified taxa represents an imposed sampling bias on subsampled screens, screen contents that contain wild seeds and worked remains. The SAC approach successfully limits costs in terms of analytical time but fails to account for the smallest seed types because it imposes subsampling at this scale. The capture of more wild species could support the original assessment of food shortfalls based on wild resource use. An alternative explanation is that these wild species were present before the onset of the late A.D. 1270s drought and missed due to subsampling. The smallest light fraction screens are also overburdened with debris and sediment, moreso than any other screen due to the pouring off of material rather than bucket flotation and skimming off of light fraction. Further testing would be helpful to assess this effect.

The concepts of redundancy and “asymptote” are problematic for archaeobotany. It is implausible to suggest that 100 per cent survey of all samples is the answer. The value of additional subsampling must be weighed against the often cost-prohibitive time required to recover taxa in sorted light fraction as done here. The question of what counts or what is worth the effort is subjective and must be made based on an assessment of cultural content. Through attempting to quantify archaeobotanical data in terms of counts or ubiquities has made more visible the challenges of assessing a method that in many respects quantifies scales of “subjectivity” in addition to “data.” The SAC approach is extremely useful in this regard, identifying that asymptote typically means, sample more and you will get more. In chapter ten I provide a cost/benefit analysis of new information from a database standpoint.

Chapter 10 Discussion: the database

All models are wrong; some models are useful.
Box et al. (2005:40)

Chapter overview

Regardless of the method, sampling is conceptualized with a goal of "representativeness." The so-called species-area relationship aims to provide the mechanism by which to achieve this goal. Decades of meticulous analyses in ecology indicate predictable patterning and mathematical regularity of certain "diversities." The idea provided a seemingly viable solution to the problem of archaeobotanical analysis and the management of archaeological material, which for the most part is retained and unwanted sediments in the case of bucket flotation and pouring off of light fraction. Sorting (screening) of light fraction into particle sizes imposes a size-based invisibility for very particular artifact classes based on retained sediment and SAC subsampling impacting the capture of small seeds and processed plant remains in the Sand Canyon Pueblo samples. Using a database approach I outline costs and benefits of archaeobotanical sampling focused on the species-area curve approach (SAC) method.

Background

The ecological pattern of increased species richness associated with increase area (area sampled) is influenced by how sampling units are selected. The same condition applies to archaeological sampling in our case, it is a "sight unseen" sampling that although a method of cluster sampling (as in collecting from a bounded accumulation of "sediment"), we have little to measure against. In archaeobotany, as in archaeology, we share similar harsh and inevitable realities of sampling a population that is ultimately unknown and unknowable in its original extent. Our added challenge is that the population is one that is also unknown in its depositional and recoverable extent. Statistician George Box and colleagues (2005:40), as noted in the quote that opens this chapter, encapsulate what is the reality of statistical methods—they represent models, and oftentimes useful ones. I have shown that the ecological approach to sampling for botanical richness using curves and concepts of sampling to redundancy fail to meet archaeobotanical goals of representative samples but are clearly useful in demonstrating bias. The "mathematical" regularity for simulated and authentic samples from Sand Canyon Pueblo is that subsampling (and categories of analysis) underrepresent "archaeobotanical diversity," specifically wild and worked remains.

It is not all bad news. The apparent truth of the species-area relationship, as clarified by Arrhenius, is that it provides "no results except to confirm the well-known and obvious fact, that the larger the area taken the greater the number of species" (1921:95). The assessment of the species-area curve approach becomes an evaluation of how we negotiate meaning from biotic data and how much we are willing to invest in the process in terms of time and effort at the risk of wasting both.

The capture of taxa, however the categories are defined, and attempting to account for interpretative potential, also reflect a database approach, one that fails to fully explore cultural content. Zohar and Belmaker's (2005:640) assessment of fishbone assemblages in faunal studies offers a deepening insight into archaeological sampling:

> As tempting as it may be to find mitigating circumstances that would allow us to trade hours of work for a "good enough" estimation of species richness, it cannot and should not be done. Increases in the number of specimens and, as a result, species richness…and taphonomic patterns are the only means by which we can correctly describe the archaeological record.

The recommendation to avoid the "good enough estimation" is a warning with far greater implications than under-sampling. By limiting analysis, we limit our recovery of archaeological facts and artifacts with an added and ominous outcome for the discipline. Limiting sampling also contributes to limiting the study of archaeology and the importance of archaeological research. This is not only a problem for archaeology. It is of serious concern for archaeobotany where the effects of underfunding make the most significant impact because of the density of our retained universe. If we say we have reached redundancy, why fund more? Plant remains exist in a matrix of persistent microscopic sediment. This "field" persists into the laboratory and by sheer volume obscures the meanings we hope to capture. Archaeobotanical samples are costly, time consuming, challenging to manage and interpret, and continue to be, in many research endeavours, too onerous. In our contemporary times of global biomass and social catastrophe, the lessons of the past are perhaps the most persuasive examples of what may be our future. In this, archaeobotany plays a pivotal role in understanding how ancient populations responded to similar concerns.

The accumulation patterning of botanical observations (this is not "distribution" in any other sense but a collection of observations) is scattered, unpredictable, and just exactly how we anticipate it to be, but hope it is not. In trying to document and quantify the results, we come up against the problem of what to count and how to count it. A fiber from a monocot, an unknown grass stem, and a cheno-am seed are "taxa," identified by recognized botanical morphological characteristics but these identities do not have much interpretative value unless considered in the larger context of taphonomy, temporality, seasonality, architecture, faunal remains, artifact evidence, abundance or rarity in very site specific depositional contexts. Most important of all is decoding ethnobotanical potential: revisiting values and motifs aligned with historical and contemporary peoples who may understand the significance at a deeper, and certainly, more culturally congruent level. A single purslane seed encountered in the fifty-eight subsample of light fraction (sample SC9) is a costly capture, its value dependent on context, its non-recognition elsewhere, its abundance and commonness (ubiquity) in relation to other remains and other samples, and its potential to contribute to what effectively is a dialogue about meaning. This evolves over the course of time, additional information, and an exploration of alternative explanations.

The concepts of redundancy, asymptote, and use of curves are clearly useful, not so much "wrong" but non-representative. Archaeologists of all inclinations have found ways to talk about their samples and their sites in useful and constructive ways. The notion of "redundancy" is appealing and clearly practical but it is not archaeologically realistic. The archaeobotanical work done in recent decades demonstrates an attention and awareness of the unique challenges of sampling "ancient." There are many ways, too, to approach large datasets and great potential for comparisons but sampling is not consistent across features and sites. And is, more often than not, subjective.

In this research I have deliberately focused on the minutia, the single light fraction screen or flotation sample, to explore the nature of the sampling process. The model may be wrong, but the process has demonstrated that various laboratory and interpretative "transforms" act on the interpretation of cultural meaning. It is at the smallest scale, the "absence" and the "rarity" of things, that we come to know more about the record. Research goals can be so constrained as to fail to account for the bigger picture, one that is undoubtedly complex and absolutely depends on minutia. It is not enough to limit the analysis by putting too much faith in one particular method or mode of explanation. Underfunding or misusing archaeology for political or commercial gains, as we have seen today in acts of terrorism, political discourse, and in media exploitation, is also a tragedy that imposes continued assault on the people we try to understand, their descendants, and the human collective. The following discussion is presented to support the view that archaeobotany is essential to the study of archaeological cultures. In this chapter I outline the costs of archaeobotany.

Study results

Several outcomes of the experimental and exploratory studies are useful in assessing archaeobotanical costs. Experimental simulations and Sand Canyon Pueblo (SCP) sample analysis demonstrate various gains and losses imposed by method, the first of which is the effectiveness of flotation for the recovery of small and minute remains.

Flotation works

The experimental study proves that flotation is excellent. The recovery rates for complete analysis of experimental firepit 5 samples demonstrate the effectiveness of flotation and the resilience of charred material (Table 10.1). The flotation "effect" is minimal. Most specimens ("exotics") introduced into the simulations were recaptured, and, retained enough morphological characteristics to assure accurate identification. Only one exotic fragmented (borage), but still retained enough traits to make identification possible.

Table 10.1 Flotation recovery: the effect of flotation on particle sizes, firepit 5 (five one-litre samples, 25 introduced seeds in a five litre "deposit") using manual (bucket) flotation processing.

Portion (mm)	Scientific name	Common name	Total introduced	Total recovered	Percent recovery
4.75	*Zea mays* L.	maize/corn	25	25	100
	Phaseolus vulgaris L.	common bean	25	25	100
	Cucurbita L.	squash	25	25	100
	Lagenaria siceraria (Molina) Standl.	bottlegourd	25	24	96
	Helianthus annuus L.	common sunflower	25	25	100
	Tropaeolum L.	nasturtium	25	25	100
			150	149	99.3%
2.80	*Piper nigrum* L.	pepper	25	25	100
	Alcea L.	hollyhock	25	25	100
	Borago officinalis L.	borage	25	24	96
	Secale cereale L.	fall rye	25	25	100
	Fagopyrum esculentum Moench.	buckwheat	25	23	92
	Lathyrus latifolius L.	perennial pea	25	25	100
			150	147	98%
1.40	*Chenopodium quinoa* Willd.	quinoa	25	18	72
	Sinapis alba L.	white mustard	25	25	100
	Physalis L.	groundcherry	25	25	100
	Lactuca sativa L.	garden lettuce	25	24	96
	Trigonella foenum-graecum L.	sicklefruit fenugreek	25	24	96
	Rosmarinus officinalis L.	rosemary	25	25	100
			150	141	94%
.71	*Papaver* L.	poppy	25	22	88
	Trifolium repens L.	white clover	25	17	68
	Apium graveolens L.	wild celery	25	21	84
	Salvia hispanica L.	chia	25	25	100
	Melissa officinalis L.	common balm	25	20	80
	Ocimum basilicum L.	sweet basil	25	20	80
			150	125	83.3%
.25	*Portulaca* L.	purslane	25	17	68
	Nicotiana L.	tobacco	25	25	100
	Mentha x piperita L.	mint	25	23	92
	Lobelia L.	lobelia	25	20	80
	Origanum vulgare L.	oregano	25	18	72
	Erogrostis tef (Zuccagni) Trotter	teff	25	6	24
			150	109	72.6%
		Grand Total	750	671	89.5%

Including the most problematic screen sizes (.71 and .25 mm), 89.5 per cent of introduced exotics were recovered in the firepit 5 experiment when accounting for unique exotics over the entire simulated "deposit." The lowest recovery rate, and one that is still remarkably good in my opinion, is for the .25 mm portion, at 72.6 per cent recovery for the minutest of seeds. When the individual species were accumulated an exceptional 100 per cent recapture of at least one specimen of each exotic in this size category was achieved. The logical conclusion: charred seeds present in flotation samples prior to processing persist after processing. These results are consistent with other experimental tests for flotation:

- Kaplan and Maina (1977) report a University of Massachusetts experimental study that recovered 40 to 90 per cent of small seeds using a flotation froth machine.
- Wagner (1982) had high recovery rates for float machine recovery, many scores well within the range of 80 to 90 per cent.
- Hunter and Gassner (1998) introduced a known quantity of different sized, deliberately charred, modern seeds into experimental flotation samples and tested their recovery under processing using a mechanical Flote-Tech flotation machine. Their results yielded a 94 to 100 per cent recovery in large to medium-sized seeds (greater than 2 mm). Recovery of small seeds (greater than 1 mm but less than 2 mm; *Papaver somniferum* [opium poppy] being one introduced seed) was 86 per cent [my recovery for this seed size is 83.3 per cent using manual flotation]. Their smallest introduced charred "exotic" (greater than .5 mm but less than 1 mm) ranged from 18 to 22 per cent recovery without considering those remains that ended up in the catchpan (<.25 mm typically an unexamined screen)[my rate of return: 72.6 per cent).
- Rossen's (1999) poppy seed test achieved 65 to 95 per cent recovery depending on sediment types using Flote-Tech flotation.
- Shelton and White (2010) record 94 to 100 per cent recovery range for introduced quinoa seeds to their hand-pump flotation system experiment. The mean in this case was 97.7 per cent recovery [my manual flotation results: 94 per cent].

Flotation is clearly an effective method for retaining light materials. It is also *excellent* (I can't stress this enough) for retaining light sediment that typically accumulates in the smallest screen sizes. The 1.4 mm, .71 mm and .25 mm portions are particularly effected, the .71 mm and .25 mm the catchment for the majority of sample sediment.

Sorting: the capture of sediments and the imposition of volume in subsampled screens

Subsampling is required in the smallest light fraction screen portions because of retained sediment not because of species diversity. Thomas' statement, "archaeology's single greatest problem is coping with the magnitude of debris" (1978:232) highlights what is an archaeobotanically specific problem.

Poor species capture (or recapture) rates is due to in large part to this retained volume load. Skimming off of light fraction could prove more effective at limiting sediment retention.

The use of geologic screens to aid in microscopic analysis can make scanning less time consuming by limiting some refocusing. However, this assures that minute sediments accumulate in the most problematic of light fraction portions imposing cost in analytical time. Subsampling using the SAC standards responds to the sediment load, not the diversity load. These portions produce the poorest results when subsampled for this reason. The result is the very real possibility of a distorted assessment of what constitutes common and what constitutes rare remains. It also results in increasing the possibility that some screens will receive more analytical attention although these are not necessarily the portions we expect, it actually guarantees that more attention will be focused on non-subsampled screens.

The effect is shown in chapter four with firepit 5 data. The plotting of “species-area” (a type of species sorting curve) and “species accumulation” (another type of species sorting curve) demonstrates how the data can be distorted. “Richness” data are those that reflect the unique variety of species of different sizes and types more akin to the “species-area” concept, if we understand this to be “richness” of species rather than “richness” of observations. For the species-area curve (SAC) approach to be meaningful as a standardized approach it must be a “sorting” curve that captures the diversity of a particular specimen size class, not screen sized content. For instance, if more species of approximately 1.4 mm in size are present, plotting a sorting curve by “specimen” size, gives a richness estimate that actually tells us there are more seeds (or fragments) of approximately 1.4 mm in size will sort. As any archaeobotanist will confirm, this is an indicator of wild seeds and possibly fragments of large things like domesticates. Of course, this is only helpful if particular features are tested, completely scanned, and enough samples evaluated to provide a reasonable estimates for standardization. Doing so is not a wasted effort. If an entire firepit or hearth content is examined and plotted as I did with firepit 5 data (“species-area” curves, vs. “species accumulation” curves) a pattern of higher richness of a particular particle size is identified. It is possible that sampling effort for that size *grade* can provide a standard by which to measure similar content in similar features. The benefit is a comparative analysis of feature use that can confirm seasonality of use, timing of use in relation to other evidence (in the case of SCP, evidence of violence), occupancy, inference potential for assessments of resource stress or differential access to resources. There is no guarantee. Sampling in this way would need to archive for future analysis of other size grades.

The problems are in the details. An accumulation curve plotted by the same *x* and *y*-axis categories (species capture by "screen" size)[114] reflects a "collection" process where the richness of the screen is actually a plot of "hits," or first observations. It makes no difference the size of the specimen, it is the identity of the specimen that is important. The 1.4 mm screen might yield species of varying size (a sorting effect for certain), but the problem lies in how the curve of such collection/observation is interpreted. If the data are used to standardize attention on a particular screen plotted through accumulation, we run the risk of never achieving the same observation pattern again but wrongly assuming that we do. There is no guarantee that light fraction screen size assures the capture of compatible seed size. Therefore, screen size is not the prime mover of species capture although it is if the screen is subsampled. Sorting and sediment are the prime movers of sampling effectiveness. Archaeobotanical light fraction material pool in unexpected screens and that is the way it is. My advice, sample richness can be conceptualized by size:

Domesticate=large=large screen sort,

Wild=small=small screen sort,

Fragments of large=small=small screen sort.

Fragments of wild=minute=minute screen sort.

The solution: sort after sample splitting and don't subsample the portion you intend to focus on. Archive the rest for future analysis!

The species-area and species-accumulation curves presented in chapter four clearly demonstrate that sorting light fraction into geologic screens will distort any assessment of asymptote (the curve) and redundancy (the effort). Relying on accumulation data to standardize sampling and subsampling will create inaccurate analytical attention to particular screen sized portions. The result can lead to the development of standardized methods with the focus on particular geologic screen size to the detriment of others and a case of imposing a false sense of replicability across a range of samples. Both caused by sorting and sediment.

Redundancy and "diversity"

The SAC approach is founded on the subsampling to redundancy concept that assumes that redundancy of sampling effort is possible and the capture of minute remains is signaled by a particular pattern of accumulation. This pattern of new species observations is a sampling (observational) bias whereby the collection of new data typically accumulate in the initial sampling phases although not for the reasons suggested by species-area research. Which is, that diversity drives

[114] The *x*-axis of "specimen" size *is* "screen" size but by labeling differently, the patterning becomes obvious. Both a "sorting" and "accumulation" curve in archaeobotany are, in fact, "sorting" curves. It is how the data are understood that can distort where attention should be focused.

the patterning. We know that collection activities contribute to the “sharply rising line that tapers off” so typical of species-area and species accumulation curves. The diversity (abundance and variety) of a light fraction sample provides species data but does not propel subsampling through species capture because the species capture is not diversity-driven, it is sediment driven (!). In most cases when more samples or subsamples were scanned both experimentally and with Sand Canyon Pueblo samples, more new species (“taxa”) were observed. Call it “asymptote” or “the SAC stopping point,” the SAC minimal volume is flexible to an extent in that it can be increased to possibly produce better results. It is unlikely to account for all available content without full analysis.

The categories of analysis used in SAC subsampling have focused on identifiable genera, species and unique parts (the difference between charcoal and seed as analytical and cultural categories). This taxonomy does not take into consideration the loss of data that occurs when clearly processed plants are present in minute form but not clearly identifiable because of fragmented or degraded morphological character traits. The result is “unknown tissue” for lack of easily describable characteristics. If the subsampling process is expanded to include more taxonomic categories based on *interpretative potential* we will be able to more fully understand or explore the content. The effect is seen if claiming “representative” samples but not including the less-than-ideal remains that could be considered “once species/now cultural.” Some may be uniquely describable.

Patterning and “common” and “rare” assessments

A major bias exposed in the experimental study is the influence of subsampling and species-area interpretation on assessments of “common” and “rare” species. All larger introduced exotics were recovered in experimental samples, all smaller, subsampled exotics were not. We see similar effects with Sand Canyon Pueblo samples. Larger specimen size assures better identification and increased likelihood that this size grade will not be lost during flotation (obviously loss is a reasonably rare occurrence!) or missed because of subsampling. The recovery of large specimens is not simply due to excellent resilience under flotation but reflects non-subsampling of this size grade. The use of curves to plot subsampling data has also contributed to misrepresented assessments of “common” and “rare” taxa. A typical species-area or species accumulation curve looks like a rapidly rising line that tapers off to horizontal to suggest rare species. The line is not a reflection of the collection process of “common” and “rare.” Both categories demonstrate an assessment bias where common species are “more observed” and rare species more accurately reflect “less observed.” That may equate to “rare” or not. Richard Ford (1988:216) provided a caution regarding “outliers” and “rare” things, one that should be continually re-evaluated because rare matters.

While flotation does impact recovery rates more with smaller particle sized materials, subsampling in the smaller screens specifically puts recovery of small wild seeds and fragments of plants at risk of noncapture and nonrecognition. It follows then, that although the full recoverable content of archaeological deposits cannot be known, we can be confident that those materials that are subsampled will be underestimated. The mathematical regularity of subsampling lies in a predictable pattern of underestimation in light fraction screens where subsampling is imposed. The cost in terms of interpretative value is the loss of wild plant content—the small and smallest seeds and fragments, the elements of the core and "delightfully diverse" Pueblo III diet that includes a wide variety of wild seeds and other parts and ground maize (Minnis 1989; Sutton and Reinhard 1995). The impact will be seen in inaccurate interpretations of domesticates vs. wild plants, the unsubsampled larger materials such as corn, beans and squash seeds that are overestimated in terms of relative importance.

"Presence," "absence," and sample selection

The designations of "present" and "absent" when applied to archaeobotanical remains can be inaccurate. As I described in chapter two, these are problematic assessments without complete analysis of samples, deposits and sites. The question always comes back to:

Is it absent because it was not used?

Not used in a particular locale?

Not available in the temporal context of the feature or the season?

Or, because we did not find it?

New genera, species and parts identified in chapter eight, Sand Canyon Pueblo (SCP) bulk volume analysis, demonstrates that analytical categories such as "presence" and "absence" creates a sense of sampling control that is tentative at best. Both categories are subsumed within species-area, species-accumulation, asymptote and redundancy concepts. I have shown that fragments of plant remains such as tissues that are not easily described in botanical terms can shed light on the processing of, in this case, maize (tissue "type 5" or maize kernel epidermis fragments is an example). Maize is not necessarily absent in latest and abandonment contexts at Sand Canyon Pueblo, it is not observed as complete kernel maize. We now understand that there are at least two very specific cuisines that may account for the "presence" and "absence" of maize: milled and non-milled food that is seasonally specific and at a finer scale, harvesting-specific. The maize harvest has either occurred leading to the preparation assuming consumption of whole kernel maize cuisine, or maize harvest has not occurred leading to the preparation and assumed consumption of milled maize (Sutton and Reinhard 1995). My contention is that Sand Canyon Pueblo was attacked to take advantage of pre-maize harvest or recent harvest. Fragments of kernels, kernel embryos, glumes, tissues and collections of *Phaseolus vulgaris* (common bean) in roof fall and on floors provide supporting evidence for the “lack” or “absence” of maize because beans are harvested before maize and ground maize leaves fragments. The evidence of beans and large game animals, ground maize and wild seeds in the same temporal context is highly suggestive of a fall hunt and feasting as proposed by Driver (2002) and Muir (1999, 2007).

The selection of only a few samples for analysis from individual features and deposits contribute to assessments of “presence” or “absence” of archaeobotanical remains. The odds of selecting the most archaeobotanically rich sample in a pool of anything more than a one sample is a reflection of how many samples were collected and the volume of the entire accumulation. When faced with tight budgets and multiple samples, one opportunity in five for good results, as was the case for experimental firepit 5, is discouraging when the goal is to capture as much information as possible. We run the risk of inferences of “scarcity” when none is present.

The notion of representative samples is an ideal that creates distorted comparative data for several reasons. Redundant sampling effort is an unreasonable standard and complete scanning of samples is impractical (exhausting and costly!). Discouraging as this is, it is even more so when considering that unless the entire “deposit” is evaluated, the best results in simulation is 63.3 per cent recapture using the SAC redundancy-based subsampling if an entire deposit is sampled. If this is the typical capture rate we can expect for real samples representing real capturable populations, then claims of redundancy and representativeness must be avoided. There is no predictable “best” sample and the data acquired simply do not reflect the quantity and quality (abundance and variety) of the capturable population. Unless additional samples are evaluated and subsampling is increased, the effect is a significantly “species”-poor dataset with the added distortion of a wild-species-poor dataset. Drennan (1996:86) calls the concept of representativeness a “slippery one” acknowledging that even if a sample is selected randomly there is no guarantee of good results, stating, “most important of all, random sampling provides a basis for estimating how likely it is that our inferences about the population are *wrong*, and thus tells us how much confidence we should place in these inferences.” It is evident that our samples are not random, they are collected from selected areas of special interest. And this makes perfect sense! I recommend not limiting analysis to archaeobotanical content but going beyond to incorporate other research to explore potential cultural meaning for archaeobotanical remains.

The most pressing concern, however, is the problem that plagues all analysis and contributes to a scarcity effect. That is, extraneous sediment volume.

Sand Canyon Pueblo study sediment load

My analysis of "new" bulk samples collected from SCP demonstrates the problem of unwanted debris—the retained sediment load of flotation analysis. New SCP bulk volume samples are documented by measured volume of each screen portion in Figure 10.1. Although these amounts include archaeobotanical remains, this has little effect on volume in the smallest screen portions. Large pieces of charcoal, maize cobs and domesticates contribute to volume amounts in the 4.75 mm and 2.8 mm screens. Sediments make up the bulk of smallest screens (Figure 10.1).

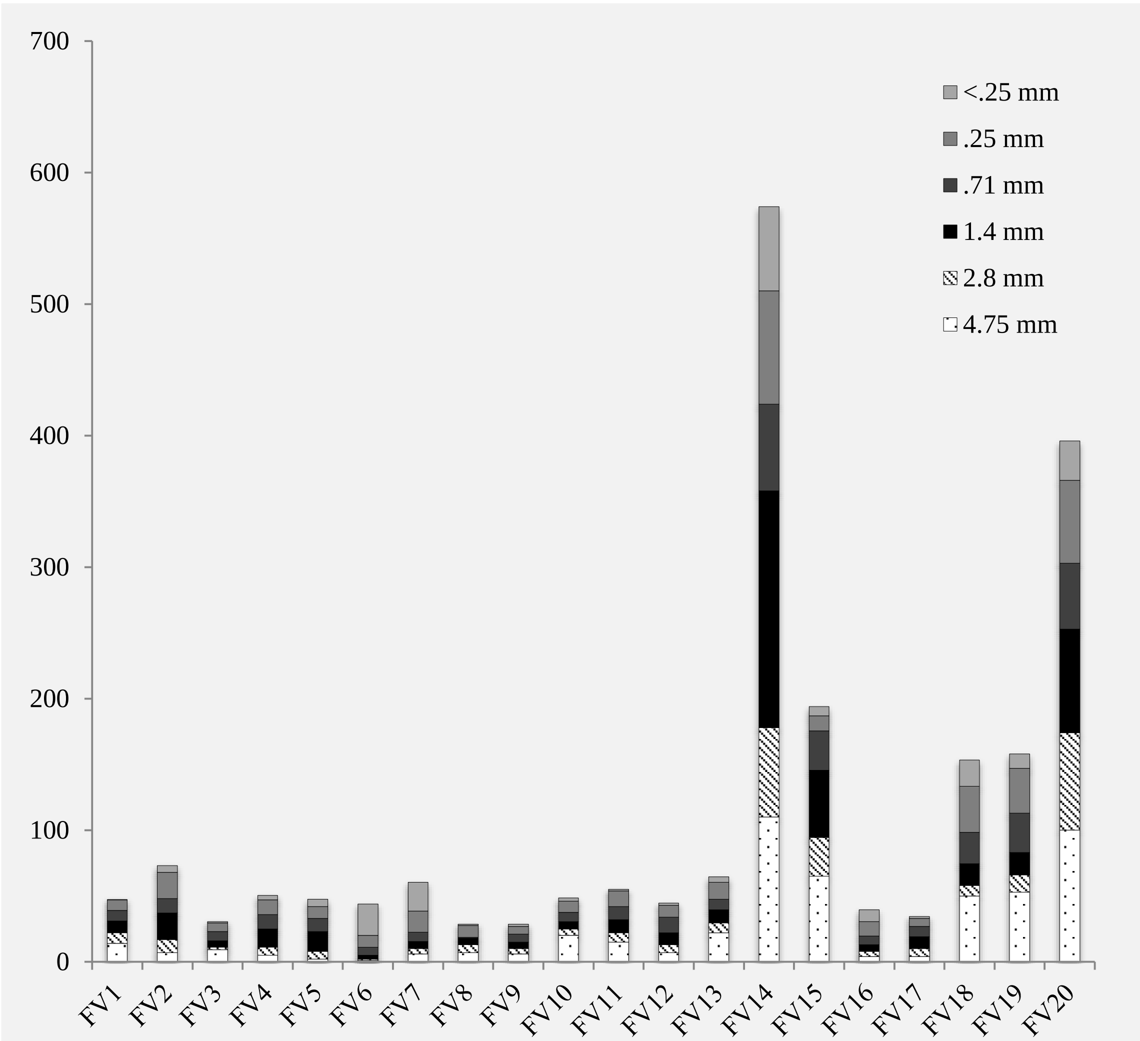


Figure 10.1 Sorting effects: retained sediment in millilitres for 20 bulk volume samples. FV1-10 are thermal feature samples and retain the least sediment volumes. Secondary refuse sample types (FV11-FV20) retain the highest sediment content in twenty flotation samples.

The light fraction recovered after flotation ranges in volume from 7 ml for an 850 ml pre-flotation volume to as high as 255 ml for a one litre pre-flotation (CV14 [not graphed] and FV14). The smallest (and subsampled screens) retained almost double the overall volume of the twenty samples I examined. In each of 20 bulk volume samples, the unsubsampled screens (light bars) are manageable because sediment sorting ensures deposition in the smallest screens. (I have also included the catchpan screen content [<.25 mm], a screen that is not routinely scanned for remains. I expected catchpan volume to be the most abundant, but this occurred only in sample FV6.). Retained sediment is most abundant for refuse samples FV14 and FV15 in comparison with the larger screens. When modeled by percentage per sample, the effect of retained sediment is more obvious. Samples FV14 (the *smoldering trash* midden in block 1200) and sample FV20 (west kiva bi-wall room) retained enormous quantities of sediment in the smaller particle sizes (Figure 10.2).

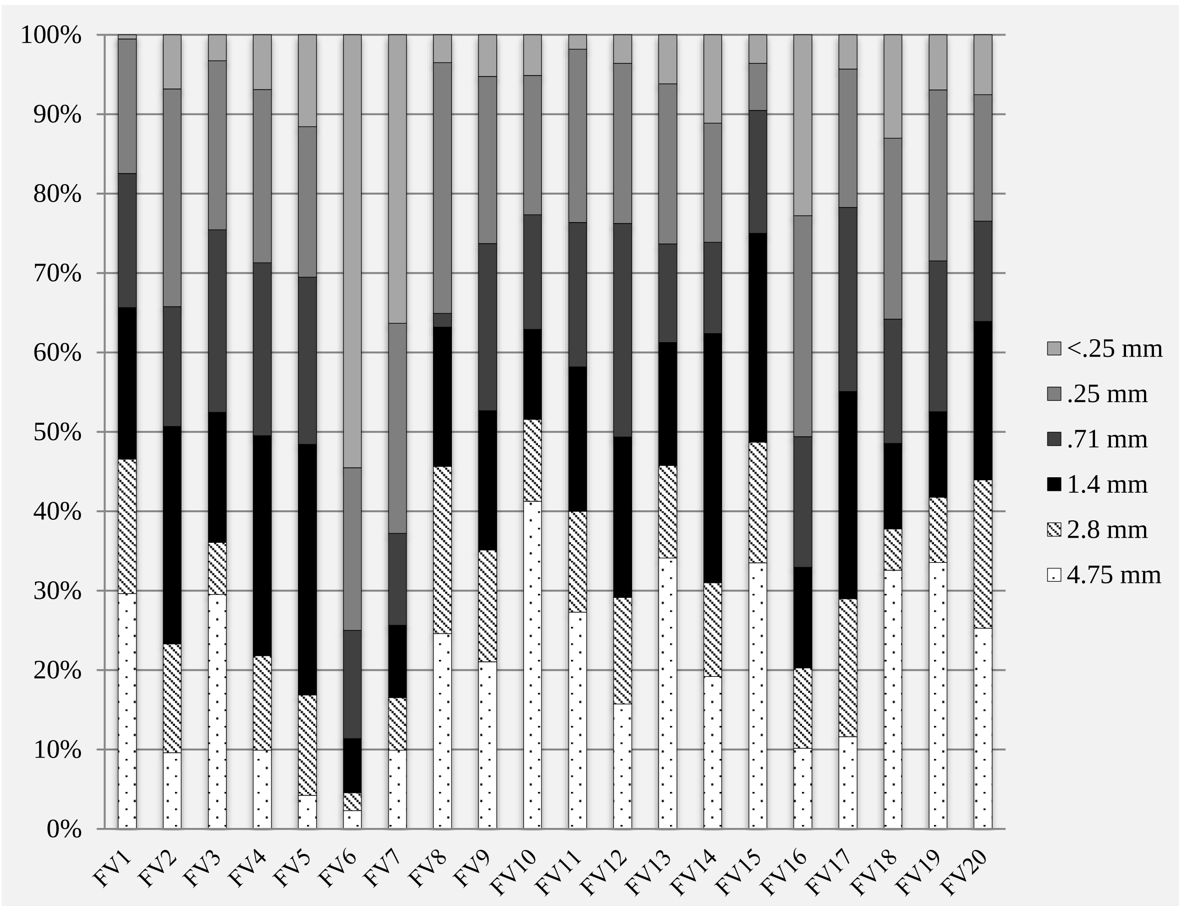


Figure 10.2 Microscopic "overburden:" percentage volume sediment for 20 sorted light fraction samples. The effect of overabundance of minute sediments is most noticeable in kiva 400 hearth sample FV6 where little plant evidence was observed in the 1 ml of sediment and debris that sorted into the 4.75 mm and 2.8 mm screens. SAC subsampling imposed in the .71 mm and .25 mm led to the examined of 4.8 ml of a total of 15 ml of material available. Based on the scant charcoal present in the larger screens (white bars), and the full analysis of the 1.4 mm screen portion (black bar), I am reasonably confident that sample FV6 contains little evidence of plant use and the sample may have been taken from a well-cleaned hearth. However, two additional one-litre flotation samples are archived for this hearth. The chances of this assessment being accurate are one in three.

Figure 10.2 also shows the effect of sorting on midden 1214 sample FV14, a sample that I focus on here because of its abundant plant evidence. Approximately 30 per cent of the sample's light fraction sorted into the 4.75 mm and 2.8 mm screens. Approximately 70 per cent of the material sorted into the subsampled portions. These screens captured 332 ml of light fraction alone. Using SAC subsampling standards I examined only 37.8 ml for these portions. If species-area curve sample SC9 from the same deposit but different layer is any indication, sample content is significantly underestimated in the small seed and fragmented or worked remains categories.

The retained sediment load in flotation samples pooling in the smallest light fraction screens shows that the 50 ml total light fraction SAC subsampling triggering volume does not account for individual screen retained sediment content. Unpredictable distribution of volume across particle sizes means that some samples receive more attention directly tied to retained sediment volume. Couple this effect with the inaccurate measuring of volumes at all stages of analysis (the .3 ml portion subsample volume for particles of .25 mm in size is obviously the most challenging to measure accurately) and it is clear that volume as a standard is problematic and volume-species relationships are entirely dependent on accuracy of measurement. I documented this effect in the SCP species-area curve analysis by measuring the screen content prior to subsampling and then accounted for subsample measures after I had scanned each subsample. The result, differences in "volume" measures can be expected.

The context and species content of the sample, regardless of volume, is meaningful in ways that override concerns over volume as a comparative measure. Similar to the argument that abundance of individual specimens is problematic for inferring differences in cultural use (see weedy species [*Verbascum thapsus*] example, pp. 50-52), it is important to recognize that the goal of flotation sample analysis is cultural content with no guarantees that volumes or mathematical measures, such as abundance, are meaningful culturally. One specimen may be all it takes.

SAC subsampled volumes are minute and quick scanning due to minute subsample volumes may save refocusing time but impose additional costs in overall analytical time because of the time and effort it takes to measure off minute subsamples.

Costs of volume

<u>Bulk samples (chapter eight)</u>

Samples with the most retained sediment are the most costly for sampling effort. Midden 1214, the stand out sample for excavated volume and content, retained the majority of its sediments in the 1.4 mm, .25 mm and catchpan (>.25 mm) screens. The 180 ml of the 1.4 mm screen content was littered with charcoal fragments and plant materials identifiable only as unknown tissues. At an average of approximately 35 minutes per subsample for measuring, scanning, and documenting, I stopped scanning at 29 subsamples, the equivalent of 26 ml of light fraction (that is, 26.1, .9 ml subsamples, analytical time investment: over 15 hours) leaving 154 ml unexamined. As outlined in Table 10.2 (next page), volumes for screen content are detailed for all FV samples. The 50 ml light fraction volume trigger for subsampling is overshadowed by the minute volumes in terms of time.

Of the 18,725 ml of archaeological dirt and matrix in the SCP bulk volume sample analyses (I include comparison volume data also), approximately 12 per cent of the overall original excavated volume was preserved in light fraction after flotation. Approximately 56 per cent of this material was scanned, accounting for approximately six per cent of the total volume excavated. Although 215.35 ml was captured in catchpan screens that typically are left unexamined, this does not account for retained sediments that make up the majority volume of the smaller and subsampled screens. Bulk samples (FV and CV) demonstrate that a 1000 ml flotation sample can yield varying quantities of light fraction. In the case of the forty-five samples evaluated for chapter seven, as little as 7 ml to greater than 500 ml was retained after flotation. The total light fraction of sample FV14 was enormous in terms of a microscopic universe (and may represent the flotation of 3000 ml rather than 1000 ml). Regardless, this sample produced the greatest variety of plants and other information. When considered in spatial and temporal context we see that late in the occupation, food and fuel resources, at least for the residents of block 1200, were abundant. Individual screen portions, however, were unmanageable in terms of volume and normal laboratory time. I spent approximately three hours to scan, identify and document taxa in the .71 mm portion of this sample alone using SAC subsampling that limited analysis to twelve subsamples. Sample SC9, also taken from midden 1214, likewise contained a huge microscopic sediment load. The analytical cost in time was enormous (weeks of scanning). In terms of budgetary considerations, the cost is prohibitive.

I modified the SAC approach in two ways for the Sand Canyon Pueblo samples to deal with retained sediments. I examined all the 1.4 mm screen contents because of ease of analysis, with the exception of FV14 where time cost became too onerous. I applied SAC subsampling to the .71 mm and .25 mm screen portions for several samples that yielded total light fraction under the 50 ml triggering volume for subsampling because of costly sediment load. I still recovered significantly more new taxa. A sorting effect is demonstrated in Table 10.2 (over).

Table 10.2 The volume problem: sorting effects on light fraction screens (ml). Portions subsampled regardless of overall light fraction volume are shaded. Screen volume data for CV samples unavailable at this writing. Columns noted in bold print highlight the distribution of materials.

Sample no.	**PD/FS No.**	**Exploratory study type**	**SCP context**	**Pre-float**	**Total light #**	**Total examined**	**Light fraction volume by portion size (ml)**							
							4.75	**2.8**	**Subtotal**	**1.4**	**.71**	**.25**	**Subtotal**	**<.25**
FV1	728/1	Burned spot 1	Arb.1 (feature 1)	900	**47.25**	37.6	14	8	**22**	9	8	8	**25**	.25
CV1a	729/1	Burned spot	Arb.1 (feature 2)	-	**30**	20	5	5	**10**	5	5	10?	-	-
CV1b	732/1	Burned spot	Arb.1 (feature 5)	-	**50**	30	5	5	**10**	10	10	20?	-	-
CV1c	737/1	Burned spot	Arb.1 (feature 7)	-	**70**	55	20	10	**30**	15	10	15?	-	-
FV2	816/2	Burned spot 2	Room 1003	1000	**73**	40.6	7	10	**17**	20	11	20	**51**	5
CV2	856/1	Burned spot	Tower 1008	750	-	-	-	-	-	-	-	-	-	-
FV3	849/2	Firepit 1	Courtyard 1000	950	**30.5**	20.5	9	2	**11**	5	7	6.5	**18.5**	1
CV3	849/1	Firepit 1	Courtyard 1000	1000	**21**	21	-	-	-	-	-	-	-	-
FV4	847/1	Firepit 2	Room 1005	1000	**50.5**	29.2	5	6	**11**	14	11	11	**36**	3.5
CV4	847/2	Firepit 2	Room 1005	1000	**33**	32	-	-	-	-	-	-	-	-
FV5	875/2	Firepit 3	Tower 1008 (feature 2)	700	**47.5**	27.5	2	6	**8**	15	10	9	**34**	5.5
CV5	874/5	Firepit	Tower 1008 (feature 1)	750	**30**	30	-	-	-	-	-	-	-	-
FV6	1454/9	Hearth 1	Kiva 400	875	**44**	8.7	1	1	**2**	3	6	9	**18**	24
CV6	1454/10	Hearth 1	Kiva 400	870	**61**	52	-	-	-	-	-	-	-	-
FV7	1481/3	Hearth 2	Kiva 517	850	**60.5**	19.1	6	4	**10**	5.5	7	16	**28.5**	22
CV7	1482/14	Hearth 2	Kiva 517	800	**59**	52	-	-	-	-	-	-	-	-
FV8	1530/2	Hearth 3	Kiva 601	1000	**28.5**	19.4	7	6	**13**	5	.5	9	**14.5**	1
CV8	1531/2	Hearth 3	Kiva 601	750	**58**	47	-	-	-	-	-	-	-	-
FV9	1432/14	Hearth 4	Kiva 1010	1000	**28.5**	22.2	6	4	**10**	5	6	6	**17**	1.5
CV9	1432/13	Heath 4	Kiva 1010	1000	**13**	13	-	-	-	-	-	-	-	-
FV10	243/5	Hearth 5	Kiva 1206	900	**48.5**	37.4	20	5	**25**	5.5	7	8.5	**21**	2.5
CV10	244/1	Hearth 5	Kiva 1206	850	**7**	7	-	-	-	-	-	-	-	-
FV11	184/126	Midden 1	Midden 209	800	**55**	35.9	15	7	**22**	10	10	12	**32**	1
CV11a	184/73	Midden 1	Midden 209	?	**20**	20	-	-	-	-	-	-	-	-
CV11b	184/76	Midden 1	Midden 209	?	**30**	30	-	-	-	-	-	-	-	-
FV12	701/40	Midden 2	Midden 515	1000	**44.6**	25.9	7	6	**13**	9	12	9	**30**	1.6
CV12	701/41	Midden 2	Midden515	1000	**68**	54	-	-	-	-	-	-	-	-
FV13	1008/112	Midden 3	Midden 803	1000	**64.5**	45.5	22	7.5	**29.5**	10	8	13	**31**	4.0
CV13a	1008/107	Midden 3	Midden 803	1000	**38**	35	-	-	-	-	-	-	-	-
CV13b	1008/113	Midden 3	Midden 803	1000	**44**	37	-	-	-	-	-	-	-	-
FV14	359/233	Midden 4	Midden 1214	1000†	**574**	215.8	110	68	**178**	180	66	86	**332**	64
CV14	359/203	Midden 4	Midden 1214	1000†	**155**	65	45	5	**50**	25?	25?	55?	**?**	-
FV15	839/145	Refuse 1	Courtyard 1000	1000	**194**	153.6	65	29.5	**94.5**	51	30	11.5	**92.5**	7
CV15a	839/144	Refuse 1	Courtyard 1000	850	**113**	102	-	-	-	-	-	-	-	-
CV15b	839/148	Refuse 1	Courtyard 1000	1000	**134**	103	-	-	-	-	-	-	-	-

continued...

Table 10.2 The volume problem: sorting effects on light fraction screens in volumes (ml). Portions subsampled regardless of overall light fraction volume are noted in shading. Screen volume data for CV samples unavailable at this writing, continued.

Sample no.	PD/FS No.	Exploratory study type	SCP context	Pre-float	Total light #	Total examined	Light fraction volume examined by portion (ml) 4.75	2.8	Subtotal	1.4	.71	.25	Subtotal	<.25
FV16	1124/186	Refuse 2	Plaza 1500	750	**39.5**	17.5	4	4	**8**	5	6.5	11	**22.5**	9
CV16	1124/184	Refuse 2	Plaza 1500	50	**36**	26	-	-	-	-	-	-	-	-
FV17	1091/17	Refuse 3	Great kiva 800	1000	**34.5**	26.2	4	6	**10**	9	8	6	**23**	1.5
CV17	1091/18	Refuse 3	Great kiva 800	1000	**23**	21	-	-	-	-	-	-	-	-
FV18	1055/4	Refuse 4	Str. 1507	1000†	**153.5**	80	50	8	**58**	16.5	24	35	**75.5**	20
CV18	1064/18	Refuse 4	Str. 1507	750	**43**	26	-	-	-	-	-	-	-	-
FV19	1259/35	Refuse 5	Str. 1511	1000	**158**	92	53	13	**66**	17	30	34	**81**	11
CV19	1259/40	Refuse 5	Str. 1511	1000†	**44**	42	-	-	-	-	-	-	-	-
FV20	1208/7	Refuse 6	Str. 1513	1000†	**396**	265.9	100	74	**174**	79	50	63	**192**	30
CV20	1208/16	Refuse 6	Str. 1513	1000	**45**	39	-	-	-	-	-	-	-	-
FV totals (only)(ml)				18725	**2172.35**	1220.5	507	275	**782**	473.5	318	383.5	**1175**	215.35

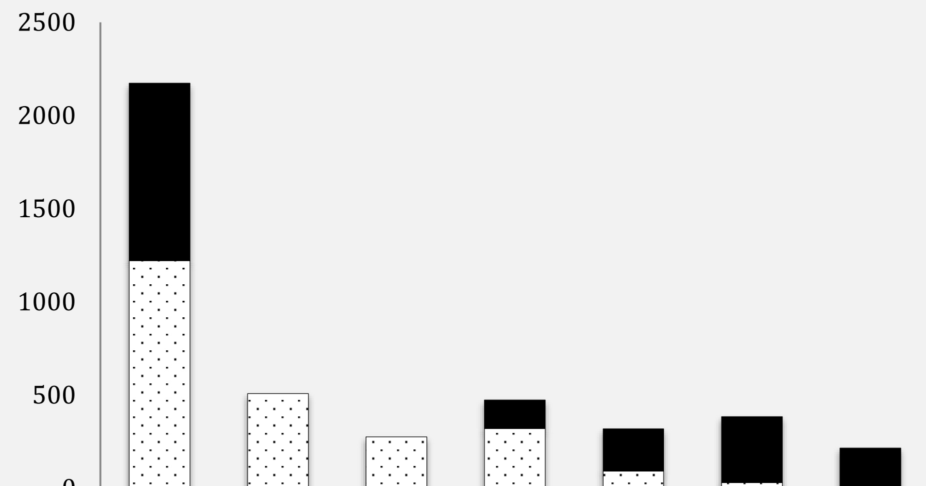
Notes:

FV Flotation volume samples analyzed by this author, CV - comparison volume samples originally analyzed and synthesized in the final report (Adams et al. 2007).

<.25 mm portion (catchpan) not typically examined.

† Original excavated volume unclear, possibly more than 1 litre. In the case of FV14 the amount could be as much as 3 litres.

The underlying purpose of subsampling is to manage analytical time reasonably. Sample FV8 is an example. Collected from the central hearth in kiva 601, the total light fraction measured 28.5 ml., 9 ml of retained sediment and debris sorted into the .25 mm screen. Divided into .3 ml volumes, this screen produced 30 individual subsamples. At an average of 10 minutes of analytical time per subsample, the .25 mm screen content of sample FV8 required five hours to measure, scan and document. Combined with the analytical costs of all other screens, the effort was time consuming and yet reflects only a small portion of the original light fraction content. The sorting effect on content can be seen in Figure 10.3.



	total light fraction	4.75 mm	2.8 mm	1.4 mm	.71 mm	.25 mm	<.25 mm
■ unexamined volume (ml)	951.85	0	0	153.9	227.7	354.9	215.35
⬚ examined volume (ml)	1220.5	507	275	319.6	90.3	28.6	0

Figure 10.3 Examined and unexamined volumes for 20 “new” Sand Canyon Puebo flotation samples. Full analysis of larger screen portions as compared with subsampled analysis of 1.4 mm, .71 mm, and .25 mm screens indicates the significant decrease in volume analyzed and the effect of volume on assessments of “common” and “rare.” Black bars account for volume unanalyzed, grey bars account for volume scanned.

The subsampling *process* eats up time. It may be minimal, but what has not been factored into the equation of sampling effort is that minute volumes are difficult to measure accurately and often require several attempts presumably redistributing material with each attempt. Of the twenty flotation samples used in testing species capture in bulk volume samples, the effect of re-measuring for subsampling introduces a “volume” effect for individual subsamples that is cumulative. Species observations can be over- or underestimated. This effect can be seen in SCP species-area curve sample analysis.

Species-area curve samples

Sand Canyon Pueblo species-area curve samples (SC1-10, chapter eight) provide information about the costs and benefits of light fraction analysis. Over-measurement of individual subsamples contributes to a decrease in calculated volumes compared to the amount actually scanned, providing additional material for analysis and possibly contributing to additional species recovery. This may not be a problem if the trend is overestimation of measuring. The opposite, under-measurement, may contribute to underestimations of species capture. My measuring tendency led to overestimation of volume per subsample for an average of a little more than one additional subsample examined for each of the ten .71 mm portions and an under-measurement of a little more than an average of one subsample analyzed for the .25 mm portion. If my results are compared to results attained by an analyst with a different measuring trend, then the risk is uneven results and incomparable results. In the case of the .25 mm portion of sample SC9 from midden (1214), I over-measured subsample volume resulting in an under-measurement of the number of subsamples I scanned. This was good news in terms of measuring and scanning fewer samples (68 subsamples vs. the estimated 70 subsamples expected based on initial portion measurement) and had no effect on species capture (my last productive subsample was 52 of 68 subsamples). I increased my chance of stumbling on new species by two subsamples for this microscopically enormous portion through incorporating more volume per subsample overall. The downside is if standardization is required for reasonably comparable samples, and such minute volumes are used where analysts cannot be assured of even measuring, the result is over-optimistic estimations of *subsampling control*. The solution is to avoid measuring subsamples. This means that however the volumes are scanned (in small amounts for ease of focusing), a decision about how much will be analyzed overall is needed. A solution is sample splitting (with a riffle box) prior to decisions about size-grade analysis. This makes sense. We have no idea what the content is and we rely on a method that worked at one feature or site, but may have no utility at others.

Do such minute discrepancies matter? They do, if we say taxa co-vary with volume. At minimum, subsampling volumes need to be accurate or at least measured with consistency comparable amongst analysts. SAC subsampling depends on minute minimal volumes and even *more* minute subsample volumes. Beyond decisions of which taxon matters enough to continue to propel subsampling, it calls into question the concept of sampling to redundancy and the optimism that attends the idea. Both operate in the same manner, decisions are made to standardize the process that rely on the view that redundancy is possible when, in archaeology, there is no such assurance. Although overall discrepancies are small and effects unknown (repeat testing is redundant because distribution is changed), it is likely that measuring and sorting distortions are multiplied, particularly when considering the standard 50 ml SAC triggering volume for subsampling. How commonly does 50 ml or any other amount of minute fractions reflect an accurate measure? “Volume”, like the concept of “representative,” is indeed a slippery one.

Volume discrepancies made by me account for overestimates of as much as eight subsamples for the .25 mm screen of sample SC1 to an underestimate of 3.67 subsamples of the same screen size of sample SC4. My pre- and post-screening measures (Table 10.3, p. 400) are well within similar measures.There is no way to calculate if such measuring tendencies contribute to “species loss” in analysis because there is no way to repeat the same analysis to account for differences. There is a way to calculate some idea of benefits in terms of species capture.

A database calculation of possible benefits of additional subsampling

Complete analysis of previously unanalyzed and subsampled smallest screen portions allow for a database approach to calculating benefits associated with additional subsampling for the ten SC samples evaluated in chapter eight. These samples (SC1-10) produced 59 new taxa based on my assessment. Some of these taxa may be new only to the deposit from which they were collected. Nevertheless, new taxa capture increases when subsampling is not discontinued in the smallest screen portions. When compared with taxa recovered in the original analysis of all screens (the “original richness” calculation) species richness virtually doubles when assessed under the same use-categories (food, fuel, other).

Table 10.3 Trends: contracting and expanding residual volumes. Measuring effects on SAC subsampling (primary refuse totals indicated by the abbreviations PR, secondary refuse totals by SR) show both over and underestimates of subsample numbers and subsample volumes. Volumes do not include amounts estimated on initial analysis prior to 2007.

	SC1	SC2	SC3[a]	SC4	SC5	Totals PR	SC6	SC7	SC8	SC9	SC10	Totals SR	ALL	AVERAGE PR	AVERAGE SR
I. VOLUME EFFECTS (ml)															
Pre-flotation volume	750	1200?	1000	1000	1000	**4950**	1000	1000	1000	1000	1000	**5000**	9950	990	995
Total light fraction	30	30	75	82	17	**234**	60	68	44	137	58	**367**	601	46.8	73.4
Original scan	22	20	66	70	16	**194**	52	54	37	97	45	**285**	479	38.8	57.0
Pre-screening measures for .71 mm and .25 mm content (measured prior to subsampling)															
.71 mm screen	4.8	2.9	9.5	14.0	5.0	**36.2**	5.0	8.3	3.5	15.0	7.9	**39.7**	75.9	7.24	7.94
.25 mm screen	8.7	6.5	7.17[a]	11.0	2.5	**35.87**	2.7	4.8	3.5	21.0	4.6	**36.6**	72.48	7.17	7.32
Post-screening measures: volumes calculated based on number subsamples scanned prior to 2007 (estimated) and number of subsamples scanned for SAC testing (actual)(ml)															
.71 mm screen	6.3	3.6	11.7	15.3	5.4	**42.3**	5.4	9.0	4.5	17.1	9.0	**45**	87.3	8.46	9.0
.25 mm screen	11.1	8.1	7.2	9.9	2.7	**39.0**	2.1	3.9	3.9	20.4	4.5	**34.8**	73.8	7.8	6.96
Volume differences: pre-subsampling and post-subsampling (ml)															
.71 mm screen	1.5	0.7	2.2	1.3	0.4	**6.1**	0.4	0.7	1.0	2.1	1.1	**5.3**	11.4	1.22	1.06
.25 mm screen	2.4	1.6	.03[a]	-1.1	0.2	**3.13**	-0.6	-0.9	0.4	-0.6	-0.4	**-2.1**	1.03	.626	-.42
II. MEASURING EFFECTS (number of subsamples)															
Estimated number of subsamples based on minimal volumes of three .9 ml subsamples (.71 mm screen) and three .3 ml per subsamples (.25 mm screen)															
.71 mm screen	5.33	3.22	10.55	15.55	5.55	**40.20**	5.55	9.22	3.89	16.67	8.78	**44.11**	84.31	8.04	8.82
.25 mm screen	29	21.67	23.92[a]	36.67	8.33	**119.59**	9	16	11.67	70.0	15.33	**122.0**	241.59	23.9	24.4
Number of subsamples scanned for species-area curve study (from previously unexamined residua)															
.71 mm screen	7	4	13	17	6	**47**	6	10	5	19	10	**50**	97	9.4	10
.25 mm screen	37	27	24	33	9	**130**	7	13	13	68	15	**116**	246	26	23.2
Number of subsamples over estimated (+) or under estimated (-)															
.71 mm screen	+1.67	+.78	+2.45	+1.45	+.45	**+6.8**	+.45	+.78	+1.11	+2.33	+1.22	**+5.89**	+12.69	1.36	1.18
.25 mm screen	+8	+5.33	.08[a]	-3.67	+.67	**+10.41**	-2	-3	+1.33	-2	-1.33	**-7.0**	3.41	2.082	-1.4

Notes:

[a] Missing data from sample SC3 .25 mm screen are accommodated for in calculated averages.

Similar to simulated samples, subsampling contributes to data loss that is also a significant interpretative loss in terms of individual samples. When calculating gains with additional subsampling, full scan of these ten samples almost doubled the number of new species accounted for (Table 10.4).

Table 10.4 Richness estimates for ten Sand Canyon Pueblo samples calculated by counting new genera, species and parts as unique taxa (charred remains only). Nonbotanical taxa not included. Shaded columns indicate full scan results.

			Screen-Based[a]				Sample-Based[b]	
			SAC approach		Full scan		SAC	New
No.	**Deposit**	**SCP context**	**.71 mm**	**.25 mm**	**.71 mm**	**.25 mm**	**approach**	**total**
SC1	Firepit	Courtyard 1000	0	0	5	2	3	10
SC2	Firepit	Room 1002	0	0	4	2	2	8
SC3	Firepit	West kiva corner room 1527	0	0	7	3	11	21
SC4	Hearth	Cleome kiva	0	0	6	1	5	12
SC5	Hearth	Kiva 600	0	0	2	1	1	4
Thermal deposits			0	0	24	9	22	55
SC6	Midden	Kokopelli kiva trash 109	0	2	1	0	7	10
SC7	Midden	Broken ladle midden 515	1	1	0	1	5	6
SC8	Midden	Great kiva trash 803	0	0	4	0	7	11
SC9	Midden	Smoldering midden 1214	2	2	10	6	15	31
SC10	Refuse	Earliest courtyard trash 513	0	1	4	1	8	13
Trash deposits			3	6	19	8	42	71
Totals			3	6	43	17	64	126

Notes:

[a] screen based richness is estimated based on complete analysis of only the .71 mm and .25 mm screen portions combined with previously estimated screen content.

[b] sample based richness is estimated based on complete analysis of only the .71 mm and .25 mm screen portions combined with all known data.

The same accounting method applied to interpretative value estimates for bulk volume samples, FV1-20, demonstrates a similar but more substantial potential for interpretative gains. I've proposed a range of potentials from minimum to maximum for these samples and considered the context for each. Minimum gains reflect the most basic categories, maximum gains take into consideration a depth of ethnobotanical and ethnographic support.

According to my accounting, a minimum of 133 interpretative gains is proposed for the analysis of 20 new flotation samples confirming that more is better. If ubiquity is the goal of analysis, these gains would not be realized to the same extent because it is the details of context that make the difference between significant and nonsignificant taxa. Ubiquities lend a false legitimacy to the data not as data, but as the basis for interpretations. Ubiquity is calculated based on presence/occurrence-type data. These can be easily generated through computer applications. However, when accounted for through contextual analysis, timing, depositional type, and other detail gained through individual context analysis, a deeper understanding of the record emerges, moving beyond a species list to a version of relevé (Tables 10.5 below and 10.6, over).

Table 10.5 Interpretative value estimates of sampling additional bulk volume: bulk volume study using simplified food, fuel and "other" use interpretative categories.

			Interpretative value estimates		Interpretative gains	
Sample	**Deposit**	**Samples compared**	**Original analysis**	**Additional analysis**	**Minimum**	**Maximum**
FV1	Burned spot	4	12	11	4	5
FV2	Burned spot	2	7	15	9	13
FV3	Firepit	2	7	6	1	3
FV4	Firepit	2	7	14	9	11
FV5	Firepit	2	13	21	9	12
FV6	Hearth	2	2	2	0	1
FV7	Hearth	2	8	6	4	4
FV8	Hearth	2	4	3	1	2
FV9	Hearth	2	2	10	5	8
FV10	Hearth	2	0	9	5	9
Subtotal	Thermal	22	62	97	47	68
FV11	Midden	3	10	12	3	6
FV12	Midden	2	5	10	4	5
FV13	Midden	3	11	13	7	8
FV14	Midden	2	10	43	30	43
FV15	Refuse	3	19	9	3	4
FV16	Refuse	2	14	11	4	6
FV17	Refuse	2	11	9	5	6
FV18	Refuse	2	4	10	6	7
FV19	Refuse	2	5	15	7	15
FV20	Refuse	2	2	28	17	24
Subtotal	Trash	23	91	160	86	124
Total		45	153	257	133	192

Notes:
Minimum interpretative gains account for number of new genera and species taking a conservative approach to interpretative values. Maximum interpretative gains account for food, fuel, and "other" uses that include seasonality as an indicator of timing. Genera such as *Pinus* are split: pinyon pine is considered new taxa in combination with *Pinus* sp. presuming that the abundant and unique resin canals of *Pinus edulis* are identifiable and that two species are present.

Table 10.6 (pp. 403-407) shows the ubiquity of taxa in thirty contexts. The data suggest that plant use remained stable through time and that, in some cases, particular assemblages such as the more obviously diverse ones, are found in particular architectural blocks. This is true of block 1200 and the D-shaped building bi-wall room contents. Midden 1214 is a particularly illuminating both for its abundance and as an example of sampling effects.

Table 10.6 New taxa: genera/species/parts for Sand Canyon Pueblo deposits by estimated time of deposition. (SC data are limited to taxa identified by me).

New taxa	Common name	Part	Condition[a]	Deposit type and earliest estimated timing		Location	Sample
Alyssum-type (cf)	madwort	seed	c	midden	ca. A.D. 1270s	mealing/storage room 1214, block 1200	SC9
Amaranthus[b]	pigweed	seed	c	refuse	ca. A.D. 1240s	beneath courtyard, block 500	SC10
				sealed firepit	ca. A.D. 1260s	D-shaped tower room, block 1000	FV5
				refuse	ca. A.D. 1260s	early plaza refuse, block 1500	FV16
				midden	ca. A.D. 1270s	mealing/storage room 1214, block 1200	FV14, SC9
				hearth	ca. A.D. 1277	kiva unknown type, block 1000	FV9
				firepit	ca. A.D. 1277	room 1002, block 1000	SC2
Amelanchier utahensis	Utah serviceberry	bud	c	midden	ca. A.D. 1270s	mealing/storage room, block 1200	FV14
				refuse	ca. A.D. 1260s	D-shaped building bi-wall room, block 1500	FV20
Artemisia tridentata	big sagebrush	achene	c, u	early firepit	ca. A.D. 1260s	courtyard 1000, block 1000	SC1
				sealed firepit	ca. A.D. 1260s	D-shaped tower room, block 1000	FV5
				midden	ca. A.D. 1270s	mealing/storage room, block 1200	FV14, SC9
		flowering heads[c]	c, u	sealed firepit	ca. A.D. 1260s	early use of tower room1008, block 1000	FV5
				firepit	ca. A.D. 1260s	D-shaped building bi-wall room 1527, block 1500	SC3
				sealed refuse	ca. A.D. 1260s	D-shaped building plaza 1500, block 1500	FV16
				midden	ca. A.D. 1270s	mealing/storage room 1214, block 1200	FV14
		charcoal	c	refuse	ca. A.D. 1240s	beneath courtyard 513, block 500	SC10
				midden	ca. A.D. 1250s	midden 209, block 200	FV11
				early refuse	ca. A.D. 1250s	early courtyard 1000, block 1000	FV15
				firepit	ca. A.D. 1260s	early courtyard 1000, block 1000	SC1
				firepit	ca. A.D. 1260s	room 1005, block 1000	FV4
				sealed firepit	ca. A.D. 1260s	early use of tower room 1008, block 1000	FV5
				hearth	ca. A.D. 1260s	kiva 1206, block 1200	FV10
				firepit	ca. A.D. 1260s	D-shaped building bi-wall room 1527, block 1500	SC3
				hearth	ca. A.D. 1270s	kiva 517, block 500	FV7
				refuse	ca. A.D. 1270s	great kiva 800 trash	FV17
				midden	ca. A.D. 1270s	great kiva 803 midden	FV13
				midden	ca. A.D. 1270s	mealing/storage room 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
				burned spot	ca. A.D. 1277	room 1003, block 1000	FV2
				firepit	ca. A.D. 1277	room 1002, block 1000	SC2
				hearth	ca. A.D. 1277	hearth, *Cleome* kiva 102	SC4
				burned spot	unknown	outside site enclosing wall, near tower 101	FV1

continued…

Table 10.6 New taxa: genera/species/parts for enhanced interpretation of Sand Canyon Pueblo deposits by estimated time of deposition, continued.

New taxa	Common name	Part	Condition[a]	Deposit type and earliest estimated timing		Location	Sample
Artemisia tridentata (cf) inferred [could also be *Chrysothamnus*] not captured above	big sagebrush	charcoal with lenticular surface†	c	midden	ca. A.D. 1250s?	midden 515	FV12
				refuse	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
				midden	ca. A.D. 1270s	great kiva midden 803, block 800	SC8
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
				hearth	ca. A.D. 1277	*Cleome* kiva 102, block 100	SC4
Artemisia tridentata	big sagebrush	leaf	c,u	midden	ca. A.D. 1270s	great kiva midden 803, block 800	FV13
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1507, block 1500	FV18
				hearth	ca. A.D. 1277	kiva 601, presumed date	FV8
Atriplex-type	saltbush	seed	c	midden	ca. A.D. 1270s	mealing/storage room, block 1200	FV14, SC9
		charcoal	c	firepit	ca. A.D. 1260s	room 1005, block 1000	FV4
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
Bromus-type	brome grass	caryopsis	c	firepit	ca. A.D. 1260s?	D-shaped building bi-wall room 1527, block 1500	SC3
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
Carabidae: *Harpalus*-type (cf)	ground beetle	elytra (forewings)	c/u?	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
Ceratoides lanata-type	winterfat	twig	c	midden	ca. A.D. 1270s	great kiva, block 800	FV13
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
Chenopodium-type[b]	goosefoot	seed	c,u	midden	ca. A.D. 1250s?	midden 515, block 500	SC7
				refuse	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
Cucurbita moschata-type	butternut squash	seed[c,d]	c,u	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
Cucurbita pepo-type	pumpkin	seed[c,d]	c,u	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
Cucurbita-type (unknown)	gourd/squash	seed	c,u	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
Cyperaceae-type	sedge family	stem	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
Descurainia-type	tansy mustard	seed	u	refuse	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
Eleocharis-type	spikerush	achene/seed	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
Ephedra	ephedra/jointfir/ Mormon tea	cone	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20

continued...

Table 10.6 New taxa: genera/species/parts for enhanced interpretation of Sand Canyon Pueblo deposits by estimated time of deposition, continued.

New taxa	Common name	Part	Condition[a]	Deposit type and earliest estimated timing		Location	Sample
Ephedra	ephedra/jointfir/ Mormon tea	stem/twig	c	midden	ca. A.D. 1250s	Courtyard 1000 refuse	FV15
				midden	ca. A.D. 1270s	Mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room, block 1500	FV20
		charcoal	c	refuse	ca. A.D. 1270s	D-shaped building bi-wall room, block 1500	FV20
Ferrian Illite/Glauconite	worked fragments	grinding agent?	u	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14,SC9
Gastropoda: *Pupoides*-type	land snail	shell	u	hearth	ca. A.D. 1277?	kiva 601, block 600	FV8
: *Vertigo*-type	land snail	shell	u	midden	ca. A.D. 1250s?	midden 209, block 200	FV11
Juncus-type	rush	achene/seed	c	hearth	ca. A.D. 1260s	kiva 1206, block 1200	FV10
Juniperus osteosperma-type	Utah juniper	modified seed/bead	u	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
		scale leaves and twigs	c, u	refuse (c)	ca. A.D. 1240s	beneath courtyard 513, block 500	SC10
				midden (u)	ca. A.D. 1250s?	midden 209, block 200	FV11
				midden (c,u)	ca. A.D. 1250s?	midden 515, block 500	FV12
				refuse (c)	ca. A.D. 1250s?	early courtyard 1000, block 1000	FV15
				firepit (c)	ca. A.D. 1260s	courtyard 1000, block 1000	SC1
				firepit (u)	ca. A.D. 1260s	courtyard 1000, block 1000	FV3
				sealed firepit (c)	ca. A.D. 1260s	D-shaped tower room 1008, block 1000	FV5
				hearth (u)	ca. A.D. 1260s?	kiva 1206, block 1200	FV10
				hearth (c,u)	ca. A.D. 1270s	kiva 517, block 500	FV7
				refuse (c,u)	ca. A.D. 1270s	great kiva 800, block 800	FV17
				midden (c,u)	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
				refuse (u)	ca. A.D. 1270s	D-shaped building bi-wall room 1507, block 1500	FV18
				refuse (c,u)	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
				hearth (c)	ca. A.D. 1277	*Cleome* kiva 102, block 100	SC4
				hearth (u)	ca. A.D. 1277	kiva 400, block 400	FV6
				hearth (c)	ca. A.D. 1277	kiva 600, block 600	SC5
				hearth (u)	ca. A.D. 1277	kiva 601, block 600	FV8
				hearth (c,u)	ca. A.D. 1277	kiva 1010, block 1000	FV9
Lagenaria-type	gourd	rind[2]	c,u	midden,	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
Mentzelia-type	stickleaf	seedcoat	u	refuse	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
Nicotiana	wild tobacco	seed	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
				hearth	ca. A.D. 1277	kiva 102, block 100	SC4

continued...

Table 10.6 New taxa: genera/species/parts for enhanced interpretation of Sand Canyon Pueblo deposits by estimated time of deposition, continued.

New taxa	Common name	Part	Condition[a]	Deposit type and earliest estimated timing		Location	Sample
Pinus contorta-type	lodgepole pine	needle	u	firepit	ca. A.D. 1260s	courtyard 1000, block 1000	FV3
Pinus edulis	pinyon pine	needle	c,u	midden (c,u)	ca. A.D. 1250s?	midden 209, block 200	FV11
				firepit (u)	ca. A.D. 1260s	courtyard 1000, block 1000	FV3
				firepit (c)	ca. A.D. 1260s	room 1005, block 1000	FV4
				refuse (u)	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
				midden (c,u)	ca. A.D. 1270s	great kiva midden 803, block 800	FV13, SC8
				midden (c)	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
				hearth (u)	ca. A.D. 1277?	kiva 601, block 600	FV8
				burned spot (u)	ca. A.D. 1277	room 1003, block 1000	FV2
Pinus edulis	pinyon pine	charcoal	c	midden	ca. A.D. 1250s?	midden 209, block 200	FV11
				midden	ca. A.D. 1250s?	midden 515, block 500	FV12
				refuse	ca. A.D. 1250s	courtyard 1000, block 1000	FV15
				firepit	ca. A.D. 1260s	room 1005, block 1000	FV4
				refuse	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
				hearth	ca. A.D. 1270s	kiva 517, block 500	FV7
				refuse	ca. A.D. 1270s	great kiva 800 trash, block 800	FV17
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1507, block 1500	FV18
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1511, block 1500	FV19
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
				burned spot	ca. A.D. 1277	room 1003, block 1000	FV2
				hearth	ca. A.D. 1277	kiva 601, block 600	FV8
				burned spot	unknown	outside site-enclosing wall near tower 101	FV1
Pinus ponderosa	Ponderosa pine	needle	c	refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
Poaceae	grass (type A)	stem	c	refuse	ca. A.D. 1270s	great kiva 800 refuse, block 800	FV17
			c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
			c	refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
	grass (type B)	stem	c	firepit	ca. A.D. 1260s	room 1005, block 1000	FV4
				midden		mealing/storage midden 1214, block 1200	FV14, SC9
	grass (type C)	stem	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
	grass (type D)	stem	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
Polanisia-type	clammy-weed	seedcoat	c	sealed firepit	ca. A.D. 1260s	D-shaped tower room 1008, block 1000	FV5
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
Purshia mexicana-type	cliffrose	charcoal	C	midden	ca. A.D. 1250s?	midden 515, block 500	FV12

continued...

Table 10.6 New taxa: genera/species/parts for enhanced interpretation of Sand Canyon Pueblo deposits by estimated time of deposition, continued.

New taxa	Common name	Part	Condition[a]	Deposit type and earliest estimated timing		Location	Sample
Sand Canyon *Malva*-type	globemallow	fruits (immature)	c	refuse	ca. A.D. 1250s	beneath courtyard 513, block 500	SC10
				firepit	ca. A.D. 1277	room 1002, block 1000	SC2
Sisymbrium/Thelyodiopsis-type	tumblemustard-type	seedcoat	c	hearth	ca. A.D. 1270s	kiva 517, block 500	FV7
Sphaeralcea-type	globemallow	seed	u	burned spot	ca. A.D. 1277	room 1003, block 1000	FV2
Stipa comata-type	needle-and-thread grass	awn	c	refuse	ca. A.D. 1260s	beneath plaza 1500, D-shaped building, block 1500	FV16
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1511, block 1500	FV19
Vaccaria-type	soapwort	seedcoat	c	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	SC9
Yucca baccata-type	datil yucca	pod	u	midden	ca. A.D. 1250s?	midden 515, block 500	FV12
		fibre, leaf	c,u	midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
				refuse	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
		stalk	c,u	midden	ca. A.D. 1270s	D-shaped building bi-wall room 1513, block 1500	FV20
Zea mays	maize/corn	glume[c]	c	firepit	ca. A.D. 1260s?	D-shaped building bi-wall room 1527, block 1500	SC3
				refuse	ca. A.D. 1270s	great kiva trash, block 800	FV17
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14
		tissue type 5 maize kernel epidermis fragments	c	refuse	ca. A.D. 1250s	beneath courtyard 513, block 500	SC10
				firepit	ca. A.D. 1260s	early courtyard 1000, block 1000	SC1
				firepit	ca. A.D. 1260s?	D-shaped building bi-wall room 1527, block 1500	SC3
				midden	ca. A.D. 1270s	mealing/storage midden 1214, block 1200	FV14, SC9
				firepit	ca. A.D. 1277	room 1002, block 1000	SC2

Notes:

[a] Condition, C: charred, U: uncharred.

[b] Previously identified as "cheno-am."

[c] Previously found only in hand-picked macrofossil samples (not flotation samples).

[d] Previously found only in uncharred form.

[e] Previously identified as "*Purshia*-type."

Midden 1214

Midden 1214 is an example of how effective additional samples can be and how vulnerable data are to sample selection. Of the over 1800 specimens identified in the original analysis collected from fifty flotation and macrofossil samples evaluated for the various layers, it required only two samples (FV14 and SC9) to provide more data than all these combined. Part luck of the draw and part limited subsampling constrained the interpretative value of the midden.

Bordered by walls and structures, midden 1214 is the most diverse accumulation excavated at SCP and one that is remarkably well preserved. Both domesticates and wild plant remains were found charred and uncharred here. The remains accumulated sometime after A.D. 1262 (CCAC 2004: Kivas, Structure 1206; Kuckelman et al. 2007). Occupying a space that transitioned in purpose at least twice over the course of occupation, the change included the decommissioning of a mealing room and storage room. Figure 10.4 (over) roughly maps out the layers of midden 1214 and includes all plant data identified in the initial analyses. Figure 10.5 (p. 410) includes all data identified by me (samples FV14 and SC9). The stratigraphic sequence is roughly mapped out on the figure showing the following layers:

- PD 403: an accumulation of material in a thin layer (PD 403) on the bedrock floor of the two rooms with various pockets of refuse filling dips in the bedrock. These were not sampled (PD 446, 451, and 407).
- PD 359: A layer overlays this lowermost strata (PD 403) and is deepest in excavation segment 1, accumulating in the space that was once a mealing room.
- PD 357: a layer that accumulated in the original storage room. Also associated with the burial.
- PD 356: This layer is the burial of a human skeleton, an adult, probably female, and material closely associated.
- PD 347: The uppermost layer at its deepest in the original storage room area with a thin layer extending into what was originally the mealing room. Segment 1 of the excavation covers the mealing room area, segment 2 covers the storage room area.
- The modern ground surface is represented by a thick bold line.

modern ground surface

arbitrary unit 1216

(relatively deep uppermost fill that extends over four structures in the general vicinity of the midden)

Excavation segment 1
original mealing room 1212

wall

Excavation segment 2
original storage room 1204

PD 359

Charcoal
Amelanchier/ Peraphyllum
Artemisia tridentata
Celtis
Cercocarpus
Chrysothamnus
Ephedra
Juniperus
Pinus
Populus/Salix
Prunus/Rosa

Domesticate
Cucurbita
C. moschata
Lagenaria
Phaseolus vulgaris
Zea mays (cob, cupule, kernel)

Wild seeds/ Other
Artemisia tridentata (flowering heads)
Capparaceae
cheno-am
Compositae
Juniperus (berry)
Leguminosae
Opuntia (seed)
Phragmites australis stems (reed cigarettes)
Poaceae stems
Yucca, Yucca baccata (fibres)

PD 347

PD 347

Charcoal
Amelanchier/ Peraphyllum
Artemisia tridentata
Cercocarpus
Chrysothamnus
Ephedra
Fendlera
Juniperus
Pinus
Purshia

Domesticate
Cucurbita
C. moschata
Zea mays (cob, **kernel, cupule**, shank)

Wild seeds/ Other
cheno-am
Physalis longifolia
Ephedra (stem)
J. osteosperma (twig)

HRO 5/PD 356
Juniperus
Pinus
Zea mays (cob, cupule)

PD 357

Charcoal
Amelanchier/Peraphyllum
Atriplex
Fendlera
Juniperus
Pinus
Prunus/Rosa

Domesticate
Zea mays (cob, **cupule, kernel**, shank)

Wild seeds/ Other
cheno-am
Leguminosae
Helianthus annuus
Physalis longifolia
Portulaca retusa
***J.osteosperma* (twig)**

wall stub

PD 359....

PD 403

Bedrock

PD 446 **PD 451** **PD 407**

Figure 10.4 Original species list (from Adams et al. 2007; CCAC 2015a): plant remains recovered from midden 1214 flotation and macrofossil (vegetal) samples based on approximate stratigraphic layers. Those PDs with no taxa noted have no record of analysis. Taxa identified in bold were recovered only in flotation samples where subsampling is routinely applied. A dashed line on the wall stub indicates inferred wall separation.

modern ground surface

arbitrary unit 1216

Excavation segment 1
original mealing room 1212

wall

Excavation segment 2
original storage room 1204

PD 347

PD 359
Bulk sample
FV14 data

Charcoal
Amelanchier/ Peraphyllum
Artemisia tridentata
Celtis
Cercocarpus
Chrysothamnus
Ephedra
Fendlera
Juniperus
Pinus
Pinus edulis
Populus/Salix
Prunus/Rosa
Purshia

Domesticate
Cucurbita
C. moschata
C. pepo
Lagenaria
Phaseolus vulgaris

Domesticate...
***Zea mays* (cob, cupule, kernel, immature kernel, kernel embryo, glume)**
Tissue type 5 (kernel epidermis?)

Wild seed/ Other
Amaranthus
***Amelanchier utahensis* (bud, twig)**
***Artemisia tridentata* (achene)**
***Artemisia tridentata* (flowering head, immature flower, leaf, twig)**
***Atriplex* (bract, seed)**
Beetle (*Harpalus?*)
***Bromus* (caryopsis)**
Capparaceae
***Ceratoides lanata* (twig)**
cheno-am, *Chenopodium*
***Ephedra* (stems, female cones, developing cones)**
Compositae
Juniperus (berry)
***J. osteosperma* (bead, leaf, twig)**
Leguminosae
Mineral (worked Ferrian Illite/Glauconite fragments)
***Opuntia* (seed, embryo)**
***Oryzopsis hymenoides* (floret)**
Phragmites australis stems (reed cigarettes)
***Physalis longifolia* (seed)**
***Pinus edulis* (bark, needle, twig)**
Poaceae stems (types A, B, C)

PD 347

PD 347

Charcoal
Amelanchier/ Peraphyllum
Artemisia tridentata
Cercocarpus
Chrysothamnus
Ephedra
Fendlera
Juniperus
Pinus
Purshia

Domesticate
Cucurbita
C. moschata
Zea mays (cob, kernel, cupule, shank)

Wild seed/Other
cheno-am
Physalis longifolia
Ephedra (stem)
J. osteosperma (twig)

HRO 5/PD 356
Juniperus
Pinus
Zea mays (cob, cupule)

PD 357 (additional plants, SC9 analysis)

Charcoal
Amelanchier/Peraphyllum
Atriplex
Fendlera
Juniperus
Pinus
Prunus/Rosa

Domesticate
Zea mays (cob, cupule, kernel, shank)
Tissue type 5 (kernel epidermis?)

Wild seed/Other
Amaranthus
***A.tridentata* (achene)**
Ceratoides lanata
cheno-am
Chenopodium
***Eleocharis* (achene, seed)**
***Juncus* (stem?)**
***J. osteosperma* (leaf, twig)**
Leguminosae
Helianthus annuus
***Nicotiana* (seed)**
Physalis longifolia
Poaceae (festucoid caryopsis)
Poaceae (A, B, D)
***Polanisia* (seedcoat)**
Portulaca retusa
J.osteosperma (twig)
Mineral (worked Fe llite/Glauconite)
Termite
***Vaccaria* (seedcoat)**

wall stub

PD 359....
***Polygonum* (achene)**
***Portulaca retusa* (seed)**
***Purshia tridentata* (leaf)**
Termite
***Yucca, Yucca baccata* (fibre, leaf)**

Figure 10.5 New species list: plant recovery with flotation analysis, midden 1214. Data based on the addition of another sample (FV14: PD 359, FS 233) and complete analysis of .71 mm and .25 mm screen portions of sample SC9 (PD 357 FS 51). Bold print are taxa identified by me. Items in plain black print represent original flotation analysis.

Highlights of midden 1214 include the following: Segment 1 (mealing room space) is most closely associated with three structures: tower 1203 is a circular tower that appears to have been abandoned prior to the abandonment of the kiva suite (CCAC 2004 Rooms, Structure 1203). Little evidence remained to infer how the tower was used or last used. Located equally close by is a "livingroom," a large and well-built rectangular space (structure 1209) with a level floor and a hearth. Hearths at Sand Canyon Pueblo are associated with kivas, making this room (and the rectangular kiva 107) in block 100 unusual. This room may have been accessed through a hatchway and was within easy access to the midden. Few artifacts were found here (exceptions: mano fragments and sherds on or near the floor)(CCAC 2004 Rooms, Structure 1209). The main kiva (kiva 1206), also located nearby, pot hunting is noted for the kiva, although it has been assessed as abandoned leisurely while the village was still occupied based on the presence of sediments below the kiva hatchway and absence of artifacts (CCAC 2004 Kivas, Structure 1206; Kuckelman et al. 2007). The refuse accumulated in midden 1214 likely came from these rooms. Based on this species list alone, the uppermost layer of midden 1214 contained similar plants to lower layers. In room 1205 located nearby a similar abundance is noted (Table 10.7):

Table 10.7 Room 1205: plant remains collected in flotation and vegetal samples in alphabetical order, charred and ancient uncharred (CCAC 2015a).

Scientific name	**Common name**	**Part**
Amelanchier/Peraphyllum	serviceberry/peraphyllum	charcoal
Artemisia tridentata	big sagebrush	charcoal
Cercocarpus	mountain mahogany	charcoal
Cucurbita moschata	butternut squash	modified seeds
Cucurbita sp.	gourd/squash	rind
Helianthus annuus	common sunflower	stem, achene
Juniperus	juniper	charcoal, seeds, shredded bark, worked wood
Malvaceae	mallow family	seed
Opuntia (prickly pear-type)	prickly pear cactus	seeds
Phragmites australis	common reed	stems
Physalis longifolia	common groundcherry	seeds
Pinus edulis	pinyon pine	cone scale
Pinus, other	pine, not pinyon	bark scale, charcoal
Populus/Salix	cottonwood or willow	charcoal
Purshia	cliffrose/bitterbrush	charcoal
Rhus aromatica var. *trilobata*	lemonade berry	seed
Scirpus	bulrush	achenes
Yucca	yucca	leaves
Zea mays	maize	cob fragments, segments, cupules

The abundance and variety of plant remains indicate that the residents of block 1200 had access to numerous plants that included a range of domesticates, a wide variety of wood resources and numerous types of wild seeds and other plant materials even after their use of the block changed. Add data collected from the analysis of another single flotation sample (FV14) and a complete analysis of the two smallest subsampled screen portions of a previously examined flotation sample

(SC9) more than indicates that midden 1214 is richer than previously thought. These are residents who were not concerned about food waste at the time of use. Similar abundance in discard is noted for the D-shaped building where domesticates and wild plants are well represented.

Chapter summary

That archaeobotanists are cautioned to focus attention on research objectives are well taken (Jones, M. 1991; Lepofsky and Lertzman 2005). However, to explore such questions as general subsistence with a focus limited to common remains runs the risk of finding what we already know to be present in Pueblo III sites across the southwest: corn, beans, squash, cheno-am, common groundcherry, and in "rare" instances purslane (because it is subsampled). This may be practical and cost effective but the idea that outliers are too problematic to deal with misses the point. With a re-analysis of the Sand Canyon Pueblo record, "rare" (*the* outlier) plays a defining role in offering new arguments for interpretations of "not-food." Plant medicine is a very special type of "not-food" that, by its very nature, should be uncommon/rare/outlier-like unless the health of the ancient residents is endemically compromised. There is clearly an argument for endemically/genetically compromised health at Sand Canyon Pueblo, at least for some. There is a context for medicinal plants that in the historic period was linked to specialized knowledge holders who are distinguished by their associations with effigy, narrative, social structure, ceremony, language and identity. Approaching the record from a data-based standpoint runs the risk of relegating such things as "rare" to lesser importance, distorting what may indeed be more culturally significant, "things" linked to special roles and social responses. On the other hand, these pharmacologically active species may not be rarely used at all, but rarely found. In chapter eleven, I show that medicine is visible at Sand Canyon Pueblo, the "other" use category in food-fuel-other investigative goals for Sand Canyon Pueblo. This next chapter demonstrates a "medicinal" toolkit of plants and material culture that confirms the importance of archaeobotanical analysis for significant insights. The discouraging effects of cost-saving measures are felt most acutely in archaeobotany because of the nature of analysis. Because of its interdisciplinary focus, archaeobotany has much to offer in the analysis of plants and the relationship of people with their material culture. An investment in archaeo-ethnobotanical research yields significant gains in deeper insights.

Chapter 11 Revisiting Sand Canyon Pueblo: cultural keystones

Native Americans were the ultimate keystone species as well as apex predators, "and their removal has completely altered ecosystems. Thus the Americas as first seen by Europeans were not as they had been crafted by God, but as they had been created by native peoples" (Kay 1995 in Dods 2002:484)

Chapter overview

Tentativeness towards relying on historical data for deeper insights has limited our ability to ground archaeobotanical and archaeological inferences in culturally described human realities. Day-to-day tragedies and the construct of belief systems motivate and act on people, the evidence of which is preserved in the archaeological record. Revisiting this aspect of sampling as the "capture of cultural taxa" allows for repositioning ideological motifs, the evidence of an enduring value system for Pueblo people. In such systems plants are fundamental and meaningful on an existential level. In this chapter I explore one of the more challenging categories of analysis for archaeobotanical data—the identification of medicine made visible by the plant record and an analysis of the significance of wild remains. Vulnerable residents of block 100 at Sand Canyon Pueblo were in need of medical intervention and the plant assemblage demonstrate the hallmarks of a medical toolkit consistent with historical Pueblo practice, practice inextricably linked with cosmological power and influence.

Background

It seems to me that any separation of myth from its empirical grounding in social, cultural, and historical contexts seriously vitiates culturally significant interpretation (Whiteley 1998:114)

Whiteley (1998) recommends a *local* theory for anthropology that is equally valid and illuminating for archaeology. Local theory captures viewpoints and perspectives and moves the analysis of ancient "sites" from restricted research categories we impose on our interpretations, into the "lived" past where the lives of ancient ancestors can be viewed as logically upstreaming in traceable ways into the traditions of descendants. The built environment of Sand Canyon Pueblo (SCP) is a language with traces in historic narrative. Two thousand years of Christian symbolism is a grammar that is readable. The rules of both privilege the existential as essential to human concerns.

Similar to the architecture of Sand Canyon Pueblo, the architecture of the 13th century European Christian church was a language. In Europe where the majority of the population could not read, the architecture was used to inform, taking its part in the liturgy, one in this case relayed in the mysteries and drama of a foreign language (Latin) unknown to most. The church was a built environment of codes and reinforcing ideology. Such ideas are embedded in how all cultures perceive themselves at an existential scale encoded in architecture. The artifact makers of Sand Canyon Pueblo left readable traces in the archaeological record through their architecture that are consistent with mythic narratives and social structure of descendant Pueblo people. Although religion is much more visible in the archaeological era of Pueblo IV, I propose that social organization founded on existential concepts can be seen clearly in Pueblo III. Sand Canyon Pueblo provides the most purpose-built and compelling example.

Archaeology is made up of what I categorize as *ethnoevidence*. The term brings to mind ideas that are not, as Whiteley (1998:15) describes, "incommunicable to others." "Ethnoevidence" captures some of the essence of what we are trying to achieve, which is to understand and convey the value of the true nature of archaeological material, the remains of which reflects the ethos of a people, not merely what they used or what happened to them. To understand something of Sand Canyon Pueblo we must understand something of human trauma and the ways in which people negotiate within a world uncontrollable.

> The play [that is, how Hopi naming expresses existential themes] rests upon certain epistemological convictions, which, were it not for the madness of the postmodern moment, seem simple truisms that would be needless to state. The first is an existential realism about human social life. The second is a belief that language can indeed describe experience, both individual and collective. Those who regard "existence," "essence," and "experience" as *only* naturalized categories may now predictably yell "Naturalism!" and "Essentialism!", though such epistemic sloganeering is a shallow path of infinite regress. Third, cultural ideas are intersubjective ... and they get expressed and acted upon in objectively describable social practices. Fourth, this intersubjectivity must—because of irrefutable species conditions of Homo sapiens sapiens—be potentially extensible across linguistic barriers; in short, just as there can be no private language, I am suggesting that there can be no private culture, whose key saliences and engagements are de jure incommunicable to others (Whiteley 1998:14-15).

These same phenomena are embedded in material culture. Ortman and Bradley (2002) describe Sand Canyon Pueblo as a "container," the village itself a containment of ethos, the pottery, a container not merely for food or a quantity of volume, but one of ideas. Even in the absence of willing and knowledgeable descendant, the epistemological convictions of the ancestors have their traces in historical ethnography. The single artifact, feature or deposit is a very particular kind of ethnoevidence or container that during its use existed within an existential realism, to use Whiteley's words. Although the breadth of linkages is daunting, historic records offer important insights. The null hypothesis applied to the process, to frame the analysis in this way, is that things are not arguably different from the past to the point of being unrecognizable. My reanalysis of Sand Canyon Pueblo archaeology shows that this is true. People change their technologies, re-tune or heighten their values, suffer illness and indignities, but how we organize and think about ourselves has consistencies.

Family and social ties are founded on deeply entrenched ideas based in metaphysical justifications. Making a case for local theory is, indeed, a *simple truism*—existential realism permeates values and is inextricably embedded in "culture" and, subsequently, the *debris* of culture.

In this chapter I return to data presented in chapter six and seven, collected and synthesized by Crow Canyon Archaeological Center researchers (CCAC 2004, 2015a; Kuckelman ed., 2007). My analysis is grounded in the following ideas:

- The ethos of a people is preserved in material culture and as such represents *ethnoevidence*.
- The existential realism of the contemporary Pueblos is also not incomprehensible (Whiteley 1998:14-15). The Ancestral Pueblo experience is not incomprehensible also. The archaeological record reflects traceable links to the ethos of the historic period.
- Archaeology, anthropology, oral histories, myths, language and social ordering are legitimate reflections of indigenous patrimony and reflect cultural affiliation with historic and contemporary descendants.
- The ethnographic and ethnobotanical record of historic Puebloans demonstrates congruency with archaeological material correlates.

Cultural "keystone species"

In their environmental mitigation work with First Nations in the Canadian North, Garibaldi and Turner (2004) developed the *cultural keystone concept* to aid land reclamation projects after environmental degradation. The approach proved fruitful for the restoration of traditional First Nations lands by focusing on the ethos of the people who resided on the land and managed its resources for thousands of years prior to the destructive process of mineral extraction. They describe the theoretical basis of the cultural keystone species concept as follows:

> Just as certain species of plants or animals appear to exhibit a particularly large influence on the ecosystem they inhabit, the same is true in social systems. We have termed these organisms "cultural keystone species" and define them as the culturally salient species that shape in a major way the cultural identify of a people, as reflected in the fundamental roles these species have in diet, materials, medicine, and/or spiritual practices...Keystone species may serve a particular culture materially in a host of different ways: as a staple food or a crucial emergency food, in technology, or as an important medicine. As well, such a cultural keystone species may be featured in narratives or have important ceremonial or spiritual roles. It would also likely be highly represented in a culture's language and vocabulary...its designation as a cultural keystone species lies in its high cultural significance (Garibaldi and Turner 2004:4).

The advantage of the keystone concept is that it resituates the environment within a cultural complex of traditional and sustainable use with time depth (the archaeological diachronic). The importance of certain plant and animal species to the success of an ecosystem encourage a reinvigorated cultural system where traditional practice can be maintained. Similar to a keystone animal or animals in an ecosystem, cultural keystones seem to dominate the "hearts, minds, social structures, morals, ideology and activities" of people (Garibaldi and Turner 2004:5). Whiteley's (1998) categorization of Hopi language as densely laconic demonstrates underlying cultural keystone concepts. I have explored this in chapter six and provide Whiteley's example, the term *Sikyakwaptiwa*, a "word image" that is particularly expansive in this regard:

Sikyakwaptiwa: The term encompasses ideas about the colour yellow, gender, sky in its translation: "he/she put yellows above on high," the word given by the Coyote clan:

> The reference is to *sikyaatayo*, 'yellow fox'... *Sikyaatayo*'s color and habits are associated in Hopi thought and tradition with the appearance of *sikyangnuptu*, a perceptually discrete stage of yellowish dawn light that follows *quoyangnuptu*, first gray light of dawn, and precedes *taalawva*, full daylight. The name, then, images the distant eastern appearance of a yellow fox in the completed act of putting the yellowness of postcrepuscular auroral light up onto the sky (Whiteley 1998:113).

In this example, colour evokes an experience of the word conveyed through existentialism. Yellow, yellow fox, a particular yellow of dawn and the act of putting up yellow is gifted by the Coyote clan, a type of "yellow fox." Although "relative, contextual and difficult to quantify" Garibaldi and Turner (2004) propose that certain attributes and combinations of attributes signal the significance of particular things ("species") as cultural keystones. Such keystones are mirrored in the yellow fox/dawn light example. In our case, reflecting the cultural significances embedded in material remains.

Earlier anthropological research also focused attention on the symbolic nature of human culture. Ortner (1973:1344) wrote of what she termed "key symbols" in the analysis of culture as "not only types of symbols, but types of symbolic functions," the analytical roots of which were founded in early anthropology, notably Ruth Benedict's *Patterns of Culture* (1934) and later analysis of Japanese symbolic systems (1967). Douglas (1966) and Turner (1967) are just two examples of the growing interest in symbolic analysis and the dichotomies and "tensions" of cultural values (Ortner 1973:1339). Her categories of key symbolism analysis are mirrored in keystone species concepts of culture, that is,

1) The natives tell us that X is culturally important.
2) The natives seem positively or negatively aroused about X, rather than indifferent.
3) X comes up in many different contexts. These contexts may be behavioral or systemic: X comes up in many different kinds of action situation or conversation, or X comes up in many different symbolic domains (myth, ritual, art, formal rhetoric, etc.).

4) There is greater cultural elaboration surrounding X, e.g. elaboration of vocabulary, or elaboration of details of X's nature, compared with similar phenomena in the culture.
5) There are greater cultural restrictions surrounding X, either in sheer number of rules, or severity of sanctions regarding its misuse (1339).

"X" is not a single element, but rather expressed within a symbolic system that is "public," one "from which the natives themselves discover, rediscover, and transform their own culture, generation after generation" (Ortner 1973:1339).

For the environmental species mitigation work of restoring traditional lands, the depth and degree of cultural connections with genera and species are required. Garibaldi and Turner (2004:5) identify the following elements that allow for the re-establishment of keystone species on the landscape to recapture the original environmental (and cultural) conditions. These are characteristics associated with,

1) Intensity, type and multiplicity of use;
2) naming and terminology in a language, including the use as seasonal or phenological indicators;
3) role in narratives, ceremonies, or symbolism;
4) persistence and memory of use in relationship to cultural change;
5) level of unique position in culture, e.g., it is difficult to replace with other available native species [in our case, "objects" and ideas];
6) extent to which it provides opportunities for resource acquisition from beyond the territory.

Ecological species on which a culture depends will be embedded in values and traditions. A cultural keystone approach to archaeological material elicits a similar response when conceptualized as a particular type of ethnoevidence. No longer merely discarded materials of particular size and shape (pottery, plants, utility), the "data," transform into something that aligns with experienced human reality. Geertz' (1973:5) "webs of significance" for anthropological phenomena can be seen in archaeological material. For the historic pueblos, associations between the power of plants and animals as "medicine" is inextricably linked with social power. All are cosmologically, logically, and socially connected. This chapter begins with analysis of the plants in the "bear" block, block 100, and its "medicines." The analytical support for my interpretation of clan organization and its underlying cosmology I identify in chapter twelve.

Sand Canyon Pueblo "cultural keystones:" the medicine

> Lion of the North, give me power to see disease
> Bear of the West, give me power to see disease
> Badger of the South, give me power to see disease
> White Wolf of the East, give me power to see disease
> Eagle of the zenith, give me power to see disease
> Shrew of the Earth, give me power to see disease
> ...My Sun Father, give me power to see disease
> ...My Moon Mother, give me power to see disease
> All [you] ancient ones, give me power
> Invocation of the Zuni Little Fire Fraternity
> (Stevenson 1904:552)

I have shown in previous chapters that methods of analysis constrain and distort interpretative potential of archaeobotanical data. A database approach to findings does indeed answer broad research questions such as "subsistence," in a general way but fails to capture deeper meanings. These constraints can be mitigated when the "data" are conceptualized as ethnoevidence and the analysis of the plant remains extends to include the "material culture" of the site. Species counts and interpretative counts reflect that database approach, providing numbers but failing to appreciate the nuance. Using the cultural keystone species concept applied to the remnants of material culture, a Sand Canyon Pueblo sociability emerges. My interpretation of this uniquely expansive SCP sociability first rests in the effigy of tower 101.

The presence and metaphoric meaning of stone effigies in the historic period, and their connection with identity and existentialism, lends considerable weight to the bear effigy as a cultural keystone that has endured from the archaeological period into contemporary Pueblo religion and social organization. Stevenson's (1904:552) reiteration of a prayer that opens this section, the ability to "see disease," reflects the transference of metaphysical power that permits certain individuals or groups to diagnose illness. The Sand Canyon Pueblo bear effigy aligns with historic Bear Clan narratives that indicate transformative healing through this artifact that finds material correlates in block 100. "All this," Parsons writes, "is close to the widespread concept of getting power from animals or plants" (1996 [1939]:189). In its metaphoric content, the bear serves as a container, one that conforms to the "cultural keystone species" concept. Scott and Aasen (1985) identified an unusual collection of plant remains in the tower (101), the unusual rectangular kiva (107), kiva 102, and midden 103. Many are ethnomedicines and pharmacologically active. I have identified seven analytical categories adapted from Garibaldi and Turner's (2004) cultural keystone attributes to demonstrate that these plant represent evidence of a medical toolkit in block 100. The keystone categories of my analysis are:

1) "Rarity." A problematic category in archaeobotany, the identification of "rarity" of use should be viewed from the initial identification of *few specimens*. A "ubiquity" of "rarity," that is, a pattern of species rarely identified may demonstrate both a sampling bias and a particular focus of use—the rare use, or contextual use, of particular plants. To attempt to separate what is truly rarely used from what is rarely identified I incorporate data from sites in the 200-km^2 area surrounding and including Sand Canyon Pueblo (Sand Canyon Locality sites) to explore the category, "rare," and the potential for outliers to reflect actual "rarity" of use. The most problematic "rare" category, of course, is small and minute seeds that are collected from subsampled light fraction that I have demonstrated impose a "rarity" factor on specimen recovery.
2) Combinations. Collections of certain genera or species in context may indicate "recipes" of ancient use that are analogous to historic/current traditional uses.
3) Ethnomedicine. Traditional and contemporary indigenous medicine sources, particularly focusing on historical Hopi and Zuni ethnobotanies, shed light on the use of certain plants as medicine.
4) Toxicity. Plants that produce toxic effects that are found in archaeological features indicate the need for specialized knowledge. This is particularly true of medicinal plants. If the dosage is inappropriate the result can lead to poisoning. Efficacy would be dependent on appropriate and cautious application.
5) Pharmacology. Contemporary research in phytochemistry and pharmacology suggests medicinal potential, often confirming the knowledge of plants in the past.
6) Disease. The health of residents and evidence of systemic disease noted on human skeletal remains as reported in Kuckelman and Martin (2007) confirm the need for medicine. Particular disease conditions and their effects require particular medicines. The plant record is robust enough to confirm the potential that certain plants were used as medicine.
7) Ideational clues. I introduce this category of analysis. I provide a brief review of keystone artifacts, artistic and architectural evidence have historical analogues testifying to a durability of "ideas" through time. These are fully explored in chapter twelve.

The remainder of this chapter is dedicated to the analysis of these categories.

Assessing rarity: NISP counts and the identification of few specimens

I have identified the signature "keystone" plant in block 100 as *Cleome* (*Cleome serrulata* Pursh. or Rocky Mountain beeplant) based on the rare identification of its seeds at SCP and at sites in the Sand

Canyon Locality and the apparent one-of-a kind rectangular pottery box found in block 100 with *Cleome* imagery gracing its interior. At approximately 10 cm (length) x 6 cm (width) x 3 cm (depth)(vessel 20, Pueblo III White Painted rectangular vessel, Structure 104 Surface 1, [CCAC 2015a:photograph numbers 3128 and 4018]), it is very small. Its use restricted to very small things. Although it could hold a quantity of seeds, the image that graces its interior is a clear stylistic match with a drawing of Rocky mountain bee plant in Underhill (1991[1946]:470) from her research with the Zuni in the 1940s. It is also a match with a diagram in Robbins et al. (1916:58). All demonstrate the distinctive palmately compound leaflets (in groups of three) and the inverted and rounded-off triangular flower head of the typical *Cleome* plant. The logical explanation for the box is as a seed container although this is not assured. Ground seeds or other powdered parts of the plant are possibilities. The box imagery tells us that this artifact held important *Cleome metaphoric* content that may not be solely related to the making of black pottery paint as typically recorded in the ethnobotanical record and usually inferred for archaeological *Cleome* seeds (see Moerman 1998). The *Cleome* plant was meaningful to someone in block 100, important enough to have a very small box decorated with its image. The controlled knowledge of religion and ceremony invested in particular people and clans indicates that this box could be a metaphoric container for power and knowledge. The potency of “medicine” as cure and as “power,” both medicinal and political, comes to mind.

The underlying metaphor of the *Cleome* box and the plant remains as a particular focus of use in block 100 requires an assessment of what is “rare” against what is “common.” I have shown that “rarity” is a problematic designation in sampled populations and thus, ubiquity measures are also problematic. However, “rarity” as a ubiquity measure may be culturally meaningful when combined with other cultural keystone categories, which I outline and explore in this chapter. I have identified 16 species that have the potential to shed light on medicines found in block 100 (Table 11.1, pp. 421-422, over). All are documented ethnomedicines. Each is addressed individually under the categories outlined. My estimates of depositional timing are based on the five-phase temporal framework outlined in chapter six. In this section, I focus attention on the research category “rarity,” and review each of the potential medicinal plants identified for block 100.

Artemisia **(*****Artemisia*** **spp.,** ***A. tridentata*****: sage, big sagebrush)(Asteraceae)**

A seed cache of more than 2000 achenes identified as *Artemisia* was found in rectangular kiva 107. I identified the achenes in an early courtyard 1000 firepit (1); the northwest sealed firepit of tower 1008 (2), in a bulk sample from midden 1214 (8) Based on data from nineteen other sites in the Sand Canyon Locality (Varien ed. 1999), very few *Artemisia tridentata* achenes have been identified: Wood’s Canyon Pueblo has a record of two charred specimens; samples from Yellow Jacket Pueblo.

Table 11.1 Unusual plants, block 100 (Number of identified specimens). New specimens identified in study samples are shaded in red. Specimen counts are recorded in brackets followed by (U) if uncharred, all others are charred and presumed ancient. Some data are noted as only "abundant," "very abundant," or "present" by the original analysts (Scott and Aasen 1985). All remains charred unless otherwise indicated (U: uncharred).

Plant Identification	Common name	Specimen type	Unit	Feature (quantity)
Artemisia-type	sage/sagebrush	seed/achene	kiva 107	east wall niche **(2,035 specimens)**
Artemisia/ Chrysothamnus	sagebrush/ rabbitbrush	charcoal	tower 101	ashpit content **(very abundant)**
			kiva 102	ash near the hearth deflector **(present)**
			midden 103	ash lens **(very abundant)**
			kiva 107	niche on east wall **(present)**
Atriplex-type	saltbush	charcoal	room 104	firepit **(1)**
Cleome-type	Rocky Mountain bee plant	seed or embryo	tower 101	subfloor ashpit **(2)**
				firepit **(3)(1U)**
				floor, east side of tower **(1)**
		seed embryos	kiva 102	bench near niche **(1U)**
			midden 103	near skeletal remains of an infant [HRO1][115] **(1U)**
				ash lens near north wall **(1)**
Chenopodium-type "cheno-am"	goosefoot and/or pigweed	seed or embryo	tower 101	floor fill **(2U)**
			arb. unit 1	burned spot near tower 101, sample FV1 (1), previous record (2)
			tower 101	subfloor ashpit **(2)**
				east side floor **(6U)**
			kiva 102	west bench near niche **(4)(12U)**
				hearth, species-area curve sample SC4 (2)
				ash near deflector **(2)**
				floor fill near hearth deflector **(2)**
				fill layer **(14)**
			midden 103	near remains of HRO 1 **(1)**
				ash lens near kiva 102 wall **(18)**
				ash lens west of HRO 1 **(43+)**
			room 105	beneath skull of HRO 2 **(3)**
				corrugated jar contents near HRO 2 **(2)(143+U)**
			kiva 107	subfloor pit vessel content, SE corner **(71+U)**
				east wall niche **(450+)(15U)**
Chrysothamnus-type	rabbitbrush	charcoal	kiva 102	collapsed structure and indeterminate fill **(15)**
Compositae-type	Aster Family: sunflower *Artemisia*	seed	tower 101	floor fill **(1U)**
			kiva 107	east wall niche **(2U)**
Cyperaceae-type	Sedge family: *Eleocharis, Scirpus*	seed	tower 101	firepit **(2)**

continued…

115 HRO 1 is the human remains occurrence (skeletal remains) of an infant of approximately 1.5-2 years of age. HRO 2 is the human remains occurrence (skeletal remains) of a 40-45 year old male (the robust but ill six-toed man)(Kuckelman and Martin 2007).

Table 11.1: Unusual plant collections, block 100, NISP (number of identified specimens). New specimens identified in the Sand Canyon Pueblo study samples are shaded. Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. For a complete listing see Scott and Aasen (1985) and CCAC (2015a). All remains charred unless otherwise indicated (U: uncharred), continued.

Plant Identification	Common name	Specimen type	Unit	Feature (quantity)
Juniperus osteosperma (as *Juniperus* sp.)	juniper*	stem, cone, seed scale leaf	tower 101	floor fill **(1U cone, +U stems)**
				subfloor ashpit **(1U cone, +U stems)**
				firepit **(5 seed, +stems) (1U cone)**
			kiva 102	bench near niche **(+stems)**
				ash near hearth deflector **(+U stems)**
				fill layer **(+U stems, 7U cones)**
				floor near hearth deflector (**+stems)(+U stems)**
				hearth, species-area curve sample SC4
			midden 103	near HRO 1 **(10U seeds, +U stems)**
				ash lens near north wall (**+U stems)**
				ash layer west of HRO 1 **(+U stems)**
			midden 109	species-area curve sample SC6 (1 twig, 6 leaves)
			room 105	beneath skull of HRO 2 **(+U stems, 17U cones)**
				corrugated jar contents near HRO **(+stems)**
Malvaceae-type	Mallow Family	seed	tower 101	subfloor ashpit **(1)(1U)**
				firepit **(1U)**
			kiva 102	fill layer **(2)**
			midden 103	ash lens near north wall **(3U)**
				ash layer west of HRO 1 **(2U)**
			kiva 107	east wall niche **(1U)**
Mammillaria-type	pincushion cactus	seed	tower 101	firepit **(21+)**
				floor, east side of tower **(1)**
			midden 103	ash lens west of HRO 1 **(6+)**
			kiva 107	firepit **(1)**
Mentzelia-type	stickleaf/blazing star	seed	midden 103	ash lens near north wall **(4U)**
			room 105	corrugated jar near HRO 2 **(1U)**
			kiva 107	subfloor pit vessel contents, SE corner **(1U)**
				east wall niche **(1U)**
Nicotiana sp.	tobacco	seed	kiva 102	hearth, species-area curve sample SC4 **(1)**
Opuntia-type	prickly-pear	seed/embryo	tower 101	subfloor ashpit **(3)**
Pinus-type likely *Pinus edulis*	pine, pinyon pine	needles	tower 101	floor fill **(14U)**
				subfloor ashpit **(2U)**
				firepit **(1U)**
			kiva 102	fill layer **(3U)**
			midden 103	near infant burial **(1U, plus seeds U)**
			room 105	beneath skull of HRO 2 **(27U)**
			kiva 107	niche east wall **(6U seeds, +U nutshells)**
Ranunculus-type	buttercup	seeds	midden 103	ash lens near north wall **(2U)**

Notes:

* Juniper and pine charcoal is ubiquitous in samples from block 100 and elsewhere. Counts are not included here.

Yellow Jacket Pueblo is the largest site in the area and only seven *Artemisia* achenes were found (CCAC 2015a). *Artemisia* achenes and seeds were limited to block 100, 1000 and 1200 at SCP. The remains of *Artemisia* charcoal is less "rarely" identified, being found in blocks 100, 200, 300, 500, 1000, 1200 and 1500. New specimens identified by me I estimate use from earliest below surface depositional contexts ca. A.D. 1240s (midden 513) until depopulation. Many specimens were collected from roof fall samples (CCAC 2015a). The record of *Artemisia* charcoal is fairly extensive for Sand Canyon Locality sites (CCAC 2015a). A seed cache of achenes does not reflect the use of big sagebrush as a fuel.

Atriplex (Atriplex spp., *Atriplex canescens*: saltbush and four-wing saltbush types*)* (Chenopodiaceae)

Previously identified only in samples from the firepit in room 104, six specimens of *Atriplex* charcoal were previously observed in SCP samples and could fit the category of "rarely used" (Table 11.2). One piece of saltbush charcoal was accounted for in midden 1214. New samples that I analyzed yielded an additional five specimens: three pieces of charcoal in block 1000, a seed and a bract in midden 1214. I estimate that *Atriplex* remains were recovered in samples deposited during phases of occupation that included a period of ideological construction and expansion in the late A.D. 1250s-A.D. 1260s until final depopulation of the village. Compared with the over 1900 specimens of juniper charcoal I counted from previously collected data (CCAC 2015a), the visibility of *Atriplex* makes it a good candidate for the interpretative category of "rarely used" at SCP. *Atriplex* is rarely identified in samples from Sand Canyon Locality sites also. The most extensively studied archaeobotanical assemblage in the area to date is Shields Pueblo where only seven pieces of charcoal are identified as *Atriplex* (Adams 2015; CCAC 2015a). Based on the data, it is reasonable to suggest that *Atriplex* was not actively sought out as a fuel source in Pueblo III contexts or its burn patterns almost entirely obliterate evidence of typical use. Its relative rarity could signal contextual use unassociated with fuel needs (Table 11.2).

Table 11.2 Ubiquity (NISP) of *Atriplex* remains based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Part**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
***Atriplex*-type**		**NISP: 1**	**NISP added: 5**
block 1000	charcoal	-	room 1005 firepit **(3)**
block 1200	charcoal	midden 1214 **(1)**	-
	bract	-	midden 1214 **(1)**
	seed	-	midden 1214 **(1)**

Chrysothamnus (rabbitbrush)(Asteraceae)

Chrysothamnus charcoal was recovered in samples from fill in the ventilation system and on or near the bench in kiva 102 (CCAC 2015a). It is unlikely the plant was deliberately placed there which would serve to block the flow of air for combustion of the kiva if this was the intention. The roof was burned and the shrub remains are probably the result of deliberate storage of the shrubs either in the kiva or on the roof for easy access as fuel for the hearth. *Chrysothamnus* recovery elsewhere at SCP is recorded in Table 11.3.

Table 11.3 Ubiquity (NISP) of *Chrysothamnus* remains based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Part**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
***Chrysothamnus*-type**		**NISP:55**	**NISP added: 12**
block 200	charcoal (C)	trash near gap in site-enclosing wall (nonstructure 201)**(2)**	midden 209 **(1)**
block 500		-	midden 515 **(1)**
block 800		-	midden 803 **(3)**
block 1000		trash in courtyard 1000 **(1)**	trash in courtyard 1000 **(1)**
		-	large room 1003 burned spot **(3)**
		kiva 1004 fill and roof fall layers **(7)**	-
		kiva 1004 hearth **(1)**	-
		-	tower 1008 sealed firepit **(3)**
		kiva 1012 hearth (test trench) **(1)**	-
block 1200		kiva 1206 roof fall **(25)**	-
		midden 1214 **(2)**	-
		excavation unit 1218 between kiva 1206 and site-enclosing wall, roof fall layer **(16)**	-
block 1500		-	plant impression bi-wall room 1507 **(2)**

The burning of kiva roofs (only kiva roofs were later burned at SCP) is thought to represent a closing ritual (Kuckelman 2007b:para 54). The question of more abundant use of shrubs such as *Chrysothamnus* towards the end of the occupation used to justify an apparent decline in the use of juniper and pine is not well supported and does not explain the evidence of *Chrysothamnus* charcoal in rooms and middens. Historically these shrubs were collected and dried on roofs as was sagebrush for ease of access for indoor fires. The *Chrysothamnus* record for SCP includes charcoal found in samples from block 200, 1000 and 1200. My study samples yielded *Chrysothamnus* charcoal in other blocks including 500, 800, and 1500. I estimate temporal deposition for the *Chrysothamnus* record from the A.D. 1250s (early ideological phase of building) until depopulation ca. A.D. 1277 indicating a duration of use of shrubs through time. Although burn patterns and subsampling likely contribute to the visibility of *Chrysothamnus*, the higher visibility of *Chrysothamnus* in later deposits is likely the result of the use and storage of the plant in certain social contexts. The apparent increase in the recovery of shrubby materials is explained by the igniting of typically stored dried shrubs on kiva roofs and stored inside kivas in handy locations for interior fires and cooking features and later utilized to ritually close kivas. The presence of juniper and pine woods in the majority of thermal features and trash accumulations is not obviously reflective of a decrease in juniper and pine and attempts to mitigate through the use of shrubs. Sampling bias, burn patterns, and cultural contexts must be considered.

Cleome (bee plant, beeweed, spiderflower)(Capparaceae)

When compared with seed counts for other species, *Cleome* seeds are rare at SCP. Original NISP counts for *Physalis longifolia* (common groundcherry) fall in the range of 380 specimens identified for SCP. Compared with 13 specimens (including *Polanisia*), *Cleome* seeds are rarely identified elsewhere although found charred and uncharred in block 100 (tower 101, kiva 102 and midden 103 (Scott and Aasen 1985; CCAC 2015a). *Cleome* is found in few deposits in the Sand Canyon Locality also: a total of 27 archaeological *Cleome* seeds have been previously identified in sites located within the 200 km^2 radius surrounding Sand Canyon Pueblo from a variety of depositional and temporal contexts which speaks to its potentially rare use and definitively "rarely identified" status (CCAC 2015a). Nine specimens, both charred and uncharred, were identified in Block 100 (Scott and Aasen 1985) (Table 11.4).

Table 11.4 Ubiquity (NISP) of *Cleome* (Capparaceae) remains based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	Part	Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)	Current analysis (bulk volume and SAC study)
***Cleome*-type**		**NISP: 2**	**NISP added: 2**
block 300	seed (C)	vessel 1 contents, a corrugated jar **(1)**	
block 1000	seedcoat (C)	-	sealed NW firepit, tower 1008 **(1)**
block 1200	seedcoat (C)	-	midden 1214 **(1)**
	seed	(identified as) Capparaceae **(1)**	-

A few unidentified Capparaceae seeds were recovered in blocks 100, 1000 and 1200 (CCAC 2015a). I identified a *Cleome* "cousin," *Polanisia* (seedcoats) in the sealed northwest firepit in the D-shaped tower room 1008 and in a sample excavated from midden 1214 (both genera have similar seed surface morphology and calls into question my identification of *Polanisia* vs. *Cleome*). Pollen samples examined by Scott and Aasen (1985) collected from block 100 provide information about the collection of *Cleome* plants. Clearly *Cleome* was used during a period of pollen production in block 100 and block 300, the shrine-like kiva and room block. Gish (1988) records *Cleome* pollen in kiva 208. In her later analysis of ethnobotanical pollen in block 500, Gish (1990:14) records *Cleome* pollen on the floor of subterranean kiva 501. The presence of pollen is an alternative explanation for the rarity of *Cleome* seeds, pollen preceding seed development. The ethnobotanical record and coprolite studies suggest that *Cleome* was an important dietary item and although the SCP record of *Cleome* seeds could be the result of poor preservation, use typified during periods of non-seeding, extreme care not to lose or discard seeds, or made less visible due to subsampling, the recovered seed record points to a rarity of use in comparison with other seed findings. *Cleome* seedcoats are durable (certainly more so than minute *Artemisia* achenes found in block 100's seed cache). Due to size and visibility, *Cleome* seeds are not as likely to be missed due to screening and subsampling. The most important factor in considering "rarity" of use for this plant is the *Cleome* box that suggests something about *Cleome* was significant for the residents of block 100. Certainly, in its latest occupation of use ca. A.D. 1277, *Cleome* seeds were part of the final days' activities more so than elsewhere.

Cyperaceae (Sedge Family): *Eleocharis* (spikerush) and *Scirpus* (bulrush)

Two unidentified Cyperaceae seeds were recovered from the firepit in tower 101 (Scott and Aasen 1985). These wetland species were also observed in samples from blocks 800, 1200 and 1500 (CCAC 2015a). Outside the village in a variety of depositional and temporal contexts a total of 52 specimens are recorded for Locality sites (CCAC 2015a). Due to size, Cyperaceae seeds and achenes are likely to be subject to subsampling and significantly underestimated. I estimate that Cyperaceae remains at Sand Canyon Pueblo were recovered in depositional contexts dated in the A.D. 1270s until final depopulation of the village ca. A.D. 1277. We can therefore reasonable presume these wetland species were used in the late occupation and continued after the onset of drought that if sampling effects do not distort the patterning, and limited to block 100, 800, 1200 and 1500 (Table 11.5).

Table 11.5 Ubiquity (NISP) of *Cyperaceae (Eleocharis, Scirpus) seeds* and achenes based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Part**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
Cyperaceae species	**seeds and achenes**	**NISP: 99**	**NISP added: approx. 35**
block 800	*Scirpus*	burned spot great kiva peripheral room 805 **(1)**	-
block 1200	*Scirpus*	"storage" room 1205 **(97)**	-
	Eleocharis	-	midden 1214 **(@35)**
block 1500	*Scirpus*	burned spot west kiva 1502 **(1)**	-

Ephedra (ephedra, Mormon tea)(Ephedraceae)

I maintain that the presence of Ephedra charcoal is the result of use of other parts of the plant, not as a deliberate fuel use strategy (pp. 316-317). The firepit in room 104 contained *Ephedra* charcoal. Other contexts include blocks 200, 800, 1000, 1200 and 1500. *Ephedra* stems/twigs are not noted outside of Sand Canyon Pueblo and the charcoal is also uncommonly identified in the Sand Canyon Locality. The total charcoal specimen count for the entire area is 68 identified in samples collected from a variety of depositional and temporal contexts (as far back as Pueblo II). The SCP record of *Ephedra* at SCP is based on temporal contexts that I estimate range from the early A.D. 1260s until the depopulation of the village. Compared with counts of juniper charcoal, ephedra/Mormon Tea is an unusual choice for fuel (Table 11.6).

Table 11.6 Ubiquity (NISP) of *Ephedra* charcoal and stems based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Part**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
Ephedra		**NISP: 35 (charcoal only)**	**NISP added: >96 (stems), 17 (charcoal)**
block 200	charcoal	corner bin room 206 **(1)**	-
block 800	charcoal	great kiva lower fill sample **(3)**	-
	charcoal	great kiva peripheral room 812 **(2)**	-
block 1000	stems/twigs	-	courtyard refuse **(2)**
	charcoal	room 1005 **(1)**	-
block 1200	charcoal	midden 1214 **(8), (1 worked)**	-
	stems/twigs	-	midden 1214 **(>94)**
block 1500	charcoal	below plaza 1500 **(19)**	-
	charcoal	-	west bi-wall room 1513 refuse **(17)**
	stems		west bi-wall room 1513 refuse **(19)**

Compositae-type seeds (Asteraceae also known as Compositae or Daisy family): *Helianthus annuus*? (common sunflower)

Other than the three uncharred seeds recovered from the tower and the niche in kiva 107, common sunflower or unspecified Compositae seeds are limited to blocks 200, 500, 1000, and 1200. I estimate temporal deposition is from the A.D. 1270s until village abandonment. The presence of *Artemisia* achenes could be represented in these identifications although other sunflower or daisy species are possible.

The record of *Helianthus* sp. or other Compositae family species for the Sand Canyon Locality where only two charred achenes of *Helianthus* sp. and *Helianthus annuus* achenes are recorded (Yellow Jacket Pueblo) have been identified. These were found in separate depositional contexts (CCAC 2015a). The visibility of the seeds could be due to timing of deposition, insufficient sampling, nonrecognition by analysts of rarity of use and/or preservation. Compared with the over 2,000 minute *Artemisia* achenes, it appears that Compositae species, other than *Artemisia* could be rare (Table 11.7, over).

Table 11.7 Ubiquity (NISP) of Compositae seeds based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Identification**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
Compositae seeds and achenes	unknown and *Helianthus annuus*	**NISP: 41 seeds/achenes, 2 stems**	**NISP added: -**
block 200	*Helianthus* sp.	tower/kiva 208 **(1)**	-
block 500	unknown type	room 511 refuse **(1)**	-
block 1000	unknown and *Helianthus* sp.	kiva 1004 mixed refuse **(9)**	
block 1200	*H. annuus*	"storage" room 1205 **(1U)(2U stems)**	-
	H. annuus	midden 1214 **(1)**	-
	unknown type	midden 1214 **(28)**	-

Juniperus/Juniperus osteosperma (juniper and Utah juniper)(Cupressaceae)

Juniper charcoal is ubiquitous across the site. It is found in burned spots, firepits and hearths and discarded in middens in other trash accumulations. *Juniperus osteosperma* (Utah juniper) twigs and scales leaves are less commonly identified. Juniper twigs were found in samples from tower 101, kiva 102, room 105 and kiva 107 (Scott and Aasen 1985); only a few were charred. The lower visibility of juniper twigs suggests that while tinder is a very plausible explanation with combustion accounting for "absence," twigs and scale leaves are resilient and not ubiquitous. Juniper twigs were found in low quantities in samples from twelve of the nineteen excavated Sand Canyon Locality sites.

Under-representation is due in part to size and sorting into subsampled screens (see Table 11.8 for new sample analysis results, p. 429, over). Uncharred remains are some cases found in contexts that also have charred evidence and in these cases I consider uncharred ancient also. Original NISP counts for juniper charcoal provides a baseline to assess the use of *Juniperus* scale leaves and twigs as less commonly used (or preserved). Juniper charcoal, scale leaves and twigs were also present in contexts I estimate were dated from ca. A.D. 1240s until ca. A.D. 1277.

Malvaceae (Mallow Family)

These specimens consist of the remains of *Malva* (*M. neglecta* [common mallow], *M. parviflora* [cheeseweed mallow]), *Sphaeralcea* (globemallow) and "Sand Canyon *Malva*" fruits. Unidentified species of mallow (Malvaceae) were found in flotation samples collected from two architectural blocks, 100 and 1200. With the exception of kiva 102, all were uncharred. These include tower 101, kiva 102, rectangular kiva 107 and midden 103 (Scott and Aasen 1985)(CCAC 2015a). If these uncharred specimens represent historic or modern contamination of the site then the visibility of the seeds should be more abundant across the site. Of the sites tested and excavated in the Sand Canyon Locality, a single charred Malvaceae-type seed was found at Castle Rock Pueblo. Yellow Jacket Pueblo flotation samples yielded two charred specimens (CCAC 2015a)(Table 11.8).

Table 11.8 Ubiquity (NISP) of *Juniperus* scale leaves and twigs (most identified to *Juniperus osteosperma*) based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Part**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
Juniperus, Juniperus osteosperma	**SL: scale leaf T: twig**	**NISP: (charred only)** **SL: 7; T: >146**	**NISP added: (charred only)** **SL:>73; T: >56**
block 100 new information		midden 109 **(1SL)(1T)**	midden 109 **(6SL); (1TU)**
			kiva 102 **(2SL)(1T); (>4SLU)(>2TU)**
			midden 103 **(3U)**
block 200		room 204 refuse **(1T)**	
		-	midden 209 **(>10SLU)(>50TU)**
		tower/kiva 208 below a surface **(1T)**	-
block 300		corrugated jar room 303 **(+TU)**	-
		burned spot room 303 **(+T); (+TU)**	-
		subfloor pit room 303 **(+TU)**	-
		kiva ("*mimic?*") 306 **(1T)**	-
block 400		test trench kiva 400 hearth	-
block 500		mealing room 503 metate bin surface **(3T)**	-
		-	very early courtyard refuse 513 **(2SL)**
		-	midden 515 **(1SL)(2T); (1SLU)(1TU)**
block 600		test trench kiva 600 hearth	test trench kiva 601 hearth **(1SLU)**
block 800		-	great kiva 800 bench refuse **(1T)(1SLU)**
		-	great kiva midden 803 **(4SL)**; **(2SLU)(4TU)**
		great kiva peripheral room 810 burned spot **(1T)**	-
block 1000		-	early courtyard 1000 firepit 1000 **(2SL);(3SLU)(2TU)**
		-	courtyard 1000 refuse **(1SL)**
		kiva 1004 mixed refuse roof fall **(11T)**	-
		two-firepit room 1005 firepit **(5SL)**	*two-firepit* room 1005 firepit **(2SLU)(1TU)**
		-	tower 1008 NW sealed firepit **(1SL)**
		kiva 1010	test trench kiva 1010 hearth **(18SL)(5T); (1TU)**
		kiva corner burial room 1017 **(1T)**	-
block 1200		kiva 1206	kiva 1206 hearth **(1TU)**
		excavation unit 1218 (near kiva 1206)**(1SL)**	-
		midden 1214 **(8T)**	midden 1214 **(>30SL)(>36T)(1 bead); (>10TU)**
block 1500		plaza 1500, below surfaces **(117T,1TU)**	plaza 1500, below surfaces **(1TU)**
		-	east bi-wall room 1507 **(1TU)**
		-	west bi-wall room 1513 **(6SL)(10T);(5TU)**
		west kiva upper storey room 1527 firepit **(1T)**	-

The apparent rarity of Malvaceae indicates that the leaves or roots were used prior to setting seeds although subsampling could also limit the visibility of the plant or, the plants served more limited purpose. Based on my estimates of depositional time, these remains were used ca. A.D. 1240s until abandonment ca. A.D. 1277 (Table 11.9).

Table 11.9 Ubiquity (NISP) of Malvaceae seeds based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Identification**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
Malvaceae seeds		**NISP: 1(U)**	**NISP added: (6)(1U)**
block 500	*Sand Canyon Malva* fruit	-	early courtyard 513 **(1)**
block 1000	*Sand Canyon Malva* fruit	-	*three-firepit* room 1003 **(5)**
	Sphaeralcea	-	large room 1003 burned spot **(1U)**
block 1200	Malvaceae	"storage" room 1205 mixed refuse **(1U)**	-

Mammillaria **(pincushion cactus)(Cactaceae)**

The record of *Mammillaria* seeds is limited to block 100. Scott and Aasen (1985) identified more than twenty-two seeds in samples from tower 101, more than six seeds were recovered from midden 103 and one specimen from kiva 107. *Mammillaria* has not been identified in any other SCP contexts or at any Sand Canyon Locality site to date (CCAC 2015a). The context of deposition is in the last day or days prior to the final attack for structures. The temporal context of the midden sample is unknown.

Mentzelia/Mentzelia albicaulis **(stickleaf, blazingstar)(Loasaceae)**

Uncharred *Mentzelia* seeds were identified in samples from a room 105 and in 107, the rectangular kiva (Scott and Aasen 1985). Thirty additional flotation volumes that I examined produced only one sample with *Mentzelia*. I identified three uncharred seedcoats in sample FV16 collected from refuse below the plaza surfaces outside the west kiva entryway to the D-shaped building. The antiquity of the specimens is supported by other uncharred and charred remains in these below surface layers, consisting of charred and uncharred *Chenopodium, Descuraina* (tansy mustard) seeds and *Artemisia* flowering heads. Charred *Mentzelia* seeds were found in samples from three Sand Canyon Locality sites: Castle Rock Pueblo Catherine's Site and Troy's Tower, a site possibly associated with SCP defense, where the hearth contained charred *Mentzelia* seeds. The block 1500 plaza refuse collection at SCP, although uncharred, is preserved under cultural surfaces and deposited some time around A.D. 1260s. The record of *Mentzelia* in the context of block 100 is the last day or days of occupation.

Nicotiana/Nicotiana attenuata (wild tobacco)(Solanaceae/Nightshade/Potato Family)

The identification and recovery of wild tobacco seeds is very rare due to the minute size of the seeds and the subsampling of light fraction. Previously a single seed was identified at Catherine's Site in the Sand Canyon Locality, but none at SCP. With additional samples, I recovered a single seedcoat of *Nicotiana* (sample SC4) from the hearth in kiva 102. Sample SC9, collected from midden 1214, also produced a single *Nicotiana* seedcoat. It is highly likely that *Nicotiana* is under-represented because of sorting and subsampling. Both "new" specimens situate use during the A.D. 1270s; in block 100, use occurred in the context of a meal or activities occurring around the time of the final attack.

Opuntia (prickly pear) cactus (Cactaceae Family)

As a Pueblo III core staple (Minnis 1989), the expectation for *Opuntia* is that the seeds will be recovered in quantity in Southwestern archaeological sites. *Opuntia* seeds also represent an element of milled pre-harvest maize cuisine (Sutton and Reinhard 1995) and the use of the pads or flowers.

The fragmented remains of maize in block 100 provide evidence that milled maize was used here late in the occupation that included ground *Opuntia* (and other cacti) seeds. It is likely that *Opuntia* served as a food here and in other areas of the village. However, prickly pear cactus is a potent ethnomedicine for its pads. The use of the pads, a traditional food and medicine item, is likely to be archaeologically invisible. The visibility of *Opuntia* in block 100 are the seeds, three specimens found in a sample collected from the subfloor ashpit of tower 101.

Of 19 Sand Canyon Locality sites assessed here, 11 yielded samples that contained *Opuntia* seeds, the most abundant record came from the larger Shields Pueblo where 205 specimens were identified (a scant few are accounted for in late Pueblo III contexts). I estimate *Opuntia* at SCP was used as early as A.D. 1250s and continued until depopulation. Interestingly, Troy's Tower, also the site of extreme violence and unusual remains (including Capparaceae seeds, *Cycloloma atriplicifolium*, the historic "lightning medicine" and war medicine of the Hopi) and warfare associations and "medicine" could be represented in both contexts. [116] Like other pharmacologically active plants found at Sand Canyon Pueblo, *Opuntia* plants have ethnographic links to warfare, ceremony, and the need for medicine (Table 11.10, over).

[116] *Cycloloma atriplicifolium* was also found at Catherine's Site, Roy' Ruin and Castle Rock Pueblo, all of which have defensive towers. If the historic record is any indication these remains represent "medicine" in the manner that they mitigated not only health concerns but also safety in warfare.

Table 11.10 Ubiquity (NISP) of *Opuntia* (prickly pear) seeds based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	Identification	Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)	Current analysis (bulk volume and SAC study)
***Opuntia* (prickly pear)**	**seeds**	**NISP: 22, 32 uncharred**	**NISP added: >30; >25 uncharred**
block 100			arbitrary unit 1 burned spot outside tower 101 **(>1)**
block 500		mealing room 503 below metate bin **(2)**	
		midden 515**(2)**	
		kiva 517 hearth **(2)**	
block 600		test trench kiva 601 hearth **(2)**	
block 800		great kiva peripheral room 810 burned spot **(4)**	
block 1000		kiva 1004 roof fall **(4)**	
		tower 1008 sealed southeast firepit **(4)(3U)**	tower 1008 sealed northwest firepit **(>28)(>25U, seed and embryos – worked?)**
block 1200		"storage" room 1205 mixed refuse fill **(9U)**	
			midden 1214 **(2)(1U embryo only)**
block 1500		below plaza surface 1500 **(14)**	
block 1500		west kiva 1502 hearth **(1)**	
		east kiva bi-wall room 1507 refuse **(20U)**	
		west kiva upper storey corner room firepit **(3)**	

***Pinus edulis* (pinyon pine) needles (Pinaceae).**

Typically inferred as a tinder material, pine needles are very durable under charring. In the case of most pine needles, a clear set of diagnostic criteria allows for easy identification on cross-section. The apparent rare identification of pinyon needles contrasts with the ubiquity of *Pinus edulis* charcoal I identified in SCP study samples. Scott and Aasen (1985) identified 17 uncharred pine needles from floor, ashpit and firepit samples in tower 101. Fill in kiva 102 yielded uncharred pine needles (three specimens). Two uncharred pine needles (plus pine seeds and nutshells) were found in the matrix surrounding HRO 1 (this is an area of the midden was disturbed by pothunters). Uncharred remains are clearly ancient in the case of the 27 uncharred pine needles found beneath the skull of HRO 2.

Pine needles are not often recorded for Sand Canyon Locality sites although nine sites have pine needles identified in flotation samples. Many samples were collected from much earlier temporal contexts than late Pueblo III (CCAC 2015a; Ryan 2015; Varien, ed. 1999). Pine needles could be unrecognized due to subsampling, fire effects, and/or their use is contextual. Additional needle fragments (not whole needles) in the smallest light fraction screens indicate that subsampling underestimates *Pinus edulis* needles for fragments. These specimens were found in layers under the plaza surfaces at the entryway to the D-shaped building (west kiva) and through time until depopulation of the village. The original NISP counts for pine wood and charcoal total 229 specimens (CCAC 2015a). Virtually all the pine I identified were pinyon and call into question pine charcoal counts for pinyon or another pine species. Regardless, the needles of pinyon pine appear to be relatively abundant although clearly impacted by subsampling (Table 11.11, Table 11.11 notes). The ethnographic use of pine needles as medicine is well documented.

Table 11.11 Ubiquity (NISP) of *Pinus edulis* (needles) based on flotation and macrofossil analysis (previous data and SCP study findings). Specimen counts are recorded in brackets followed by (U) if uncharred. All other counts are charred and presumed ancient. Uncharred remains are considered ancient unless further specified.

Identification and architectural block	**Identification**	**Previous analysis of SCP contexts excluding block 100 (CCAC 2015a)**	**Current analysis (bulk volume and SAC study)**
Pinus edulis	**needles**	**NISP: 4U**	**NISP added: 81; 33(U)**
block 100	additional evidence	midden 103 **(1U)** tower 101 firepit **(3U)** kiva 102 fill **(1U)**	
block 200		-	midden 209 **(1)(22U)**
block 600		-	test trench kiva 601 hearth **(1U)**
block 800		-	great kiva midden 803 **(>15)*(3U)**
block 1000		-	courtyard 1000 early firepit **(1U *P. contorta*)(1U *P. edulis*)**
		-	large room 1003 burned spot **(1U)**
		-	*two-firepit* room 1005 firepit (**1**)
block 1200		-	midden 1214 **(46)(14)****
block 1500		-	plaza 1500 below surfaces **(3U)**
		-	west bi-wall room 1513 **(6: *P. ponderosa*)**

Notes:

* This needle collection is important for assessing the visibility of needles in flotation samples. The over 15 charred needles noted here, all were found through complete analysis of the smallest light fraction screens (.71 mm and .25 mm, sample SC8). Assessing ubiquities for fragmented remains is a tentative business at best.

** Fourteen additional specimens are accounted for midden 1214 by complete analysis of sample SC9.

Ranunculus (buttercup)(Ranunculaceae Family)

Uncharred *Ranunculus* seeds were recovered in a flotation sample collected from an ash lens in what I have labeled the "*Sandhill crane*" midden (103). No other sites in the Sand Canyon Locality have a record of *Ranunculus*. Although uncharred, it is plausible that excellent preservation contributed to its recovery and other uncharred seeds and other plant parts in the midden and block 100 testify to the same. The visibility of *Ranunculus* is so limited and seeds are small, subsampling effects or special use is intimated rather than seed rain from nonarchaeological sources.

NISP counts and "rarity" assessments are tentative at best, particularly when considering fragmentation or durability through fire alteration, preservation, and sampling effects. When compared with other NISP counts, however, a sense of comparative "commonness" and "rarity" emerge. I have identified these particular plant remains as having the interpretative potential for analysis of medicinal use for several reasons. The question of resource stress as a push factor in the events of the final years in the Mesa Verde area relies on interpretations of the plant record built on assessments of the ubiquity of particular plants. Any inferences of commonality or rarity of specimens requires an assessment of how ubiquity measures are used. These must include an analysis of seasonality. The context of a fall raid imposes conditions on plant use that would include seasonally available food sources such as *Opuntia* (prickly pear) seeds and other fall season foods like *Physalis longifolia*, typical Pueblo III food plants that are fall season resources. An apparent decreased visibility of maize if pre-harvest, or as a consequence of raiding for corn, is an alternative explanation for lack of whole or clearly recognizable maize remains. I am not saying that such plants were not subsistence resources; rather I am proposing an alternative explanation for their ubiquity and visibility. To build on this argument, plants found in combinations may also shed light on alternative explanations.

<u>Combinations and toxicity: looking for "recipes" and considering toxic effects</u>

> In doing herbs studies with our old people, real potent medicine sometimes comes in pairs
> and they both resemble each other but one of them's poisonous.
> That's why only the people that really knew about the medicine,
> prayed about it and sometimes the holy people, when they treated somebody that was sick
> they would be revealed [...] what kind of medicine was supposed to be used...they were led to which one it is.
> Apache consultant 2003 (Toupal and Stoffle 2004).

> Residents of rural areas should be educated to avoid the consumption of wild plants
> [due to lack of knowledge of toxicity effects]
> (Yanardag Acik et al. 2012:281).

Admitted to hospital on an emergency basis, a 45-year-old diabetic patient was found to have consumed quantities of *Chenopodium polyspermum* (manyseed goosefoot) as a herbal remedy to manage his blood glucose levels. The result: chronic renal failure requiring dialysis and other medical supports (Acik et al. 2012). One of the physicians' group recommendations for future cases included investigations into *C. polyspermum* for toxicity and the caution I have reiterated above. As a medicine used for the treatment of intestinal parasites in the Archaic (Reinhard et al. 1985) into the historic period and noted in herbal remedies today, nonjudicious consumption of *Chenopodium* can lead to unwanted and, in the case above, dire effects.

Speculating on plant combinations and controlled knowledge and judicious use of particular plants factors into considerations of plant evidence. Toupal and Stoffle's (2004) Apache consultant (in the quote that introduces this section) tells how humans have acquired knowledge of plant medicines, knowledge that has been lost through time, creating a disconnect with the natural world. The pairing of toxic and nontoxic plants as "potent medicines," known by only a few, hints at the deep history of effective indigenous medicines. In support, recent pharmacological research has turned to ethnobotanical sources of indigenous plant use in efforts to develop new medicines. Some of the plants found in block 100 can have toxic effects if used inappropriately; however, their combinations can shed some light on the last days and weeks of the occupancy of block 100. My analytical "keystone species," *Cleome* (seeds) was found in combination with six other species (both charred and uncharred): *Juniperus osteosperma* (Utah juniper) twigs and scale leaves; *Pinus* (pine)(unspecified species) needle fragments; *Mammillaria* (pincushion) cactus; *Malvaceae* (Mallow Family); *Mentzelia* (blazingstar) and *Opuntia* (prickly pear). A culturally important and rarely identified or recovered *Nicotiana* (wild tobacco) seed was also identified in a hearth sample taken from kiva 102. Pollen samples were also evaluated for the block (Scott and Aasen 1985) and these are considered as part of a suite of plants that conform to an historical medical toolkit. The tradition of medicine controlled or owned by Pueblo clans indicates that certain knowledgeable individuals and societies may have been vested in the knowledge in the effects of such species.

One of the intriguing findings of tower 101 is its *Allium* (wild onion)(Liliaceae) pollen content. *Allium* pollen was found in samples from the floor near the ashpit in tower 101 as was *Calochortus* (mariposa lily), *Cleome*, *Portulaca* (purslane), *Sphaeralcea* (globemallow) and Asteraceae (Aster Family)(Scott and Aasen 1985:4). In addition to the firepit and ashpit content, one of the two niches in the tower located near the entry into rectangular kiva 107 contained a slab metate where small quantities of *Allium*, *Cleome* and Cheno-am pollen were identified (Scott and Aasen 1985). *Allium* pollen was found in a wall niche in kiva 107 along with *Cleome*, Solanaceae (Nightshade/Potato Family) and a large quantity of cheno-am pollen (14). No macrofossil evidence of wild onion has been recovered at SCP and the ubiquity of *Allium* pollen is unknown, pollen sampling was very limited at the site. The typical size of a niche at SCP, however, makes these features unlikely locations for bulk food storage. Niches in the historic period were used for effigies and important ritual items (Fewkes 1902; Parsons 1996 [1939]). A consideration of the toxicity of *Allium* toxicity hints at controlled use (summarized in Table 11.11). *Allium* is also known for its pharmacological activity.

The evidence presented by Scott and Aasen (1985) for the tower, kivas 102 and 107 and the midden indicate that toxicity could be a factor in the combinations of plants found in the tower. The plants identified by Scott and Aasen and Adams (CCAC 2015a) for the tower, kivas 102 and 107, and the midden include charcoals, seeds and parts. Charcoal was dominated by juniper and pine with sagebrush/rabbitbrush materials found on floors in the vicinity of thermal features and tower ashpit content. These species clearly fit the historical practice of fuel woods. Remains of shrubs of sagebrush, saltbush and ephedra are unusual at SCP. Sagebrush produces aromatic smoke, *Atriplex* and *Ephedra* are poor indicators of fuel use for their productivity. All have toxic effects.

Remains of sagebrush, saltbush, and ephedra are unusual finds at SCP. Sagebrush produces aromatic smoke, *Atriplex* and *Ephedra* are poor indicators of fuel use for their slow growth and productivity. All have toxic effects (Table 11.11). In this respect the firepit in room 104, so close in proximity to the human remains of the next room (the robust man), are inconsistent with discard of plants used for other purposes than typical wood choices for fires is a combination of juniper, pine and rose. It can be argued that edible plants such as *Chenopodium*, *Opuntia* and Malvaceae represent a milled maize cuisine consistent with Pueblo III staple diet. Ground maize evidence is present in the firepit and ashpit contents of tower 101. The same remains were identified from samples taken in kiva 107: in the hearth, the niche, on the floor and in a subfloor pit vessel and it is clear that milled food was stored and used here. *Opuntia* seed counts are low, perhaps testifying to seed use as ground with maize or, more the use of other parts of the plant particularly in light of health concerns here. The combinations of “rare” or rarely identified remains suggest ethnomedicines. The pharmacological potential of these species speak to managed toxicity. As an indicator of judicious use, toxicity’s opposite, judicious *dosing*, often produces medicinal benefits (Table 11.12, pp. 437-440).

Table 11.12 Combinations and toxicities: exploring the judicious use of plants in block 100 with selections from other unusual depositional contexts. In all cases, with the exception of *Allium*, block 100 plants are found in midden 1214.

Selected plants	Cultural contexts	Combinations that include selected plants[a]	Toxic parts	Toxicity factors for selected plants
Allium (Liliaceae) particularly	Kiva 107 wall niche	*Allium*, *Chenopodium*, *Cleome*, Solanaceae pollen	Leaves and bulbs	Anemia (Ross 2001:19). Allergic reactions, bronchial asthma, rhinoconjunctivitis, contact dermatitis (7). Nelson et al. (2007:73) records systemic poisoning in humans. *Allium canadense* L. (wild garlic, wild onion) is one of four species most associated with human poisoning due to acute, substantial or chronic ingestion of the bulbs.
Artemisia (Asteraceae) particularly *A. filifolia* Torr. and *A.tridentata* Nutt.	Kiva 107 seed cache also found in midden 1214 (achene)	Seeds of cheno-am, Malvaceae and *Mentzelia* and *Juniperus osteosperma* twigs. See also *Atriplex* below. Midden 1214 contains similar variety and more. Sparse remains are noted for room 303 (Scott and Aasen 1985)	Branches, leaves	Acute ingestion leads to vomiting, restlessness, delirium and seizures, chronic use can lead to gastritis, pica [a craving for "unnatural" foods such as dirt, clay or sand (Friel 1977:536)], tremours and seizures (Burrows and Tyrl 2013:161-164). Can result in abortion in grazing animals (Johnson et al. 1976). Malvaceae species are toxic to grazing animals (see below). *Mentzelia* toxicity unknown.
	Tower 1008 sealed firepit	Cheno-am, Capparaceae seed and *Opuntia* seeds, *Artemisia tridentata* achene, leaves, flowering heads and charcoal. *Chrysothamnus* charcoal and *Juniperus osteosperma* twigs.		
Atriplex (Chenopodiaceae)	*Cleome* pottery box room 104 firepit	*Ephedra*, *Cercocarpus*, *Artemisia tridentata*, *Juniper* charcoal. This firepit contains an unusual collection of fuel wood when compared to most SCP thermals features where juniper, pine and rose species dominate.	Branches, leaves	Toxicity is due to soil conditions leading to high levels of nitrate, oxalate, selenium and sulfur in these plants. Most notable for *Atriplex* is oxalate, selenium and sulfur accumulation. Over consumption in animals can lead to digestive disturbance and neurological effects (Burrows and Tyrl 2013:339-340). *Artemisia*, *Ephedra* and *Juniperus* can be toxic (see below).
Chenopodium (Chenopodiaceae)	Room 105, a collection of cheno-am seeds and many embryos beneath HRO 2	*Mentzelia* seed, *Juniperus osteosperma* twig.	Leaves	Plants where high levels of nitrogenous runoff, high potassium and low phosphorus in the soil can be especially toxic due to excessive oxalate accumulation in the plant (Burrows and Tyrl 2013:339). Although rare in humans, some *Chenopodium* species can cause or contribute to tremours, hypocalcemia in ruminant animals. Milk can be tainted from fresh goosefoot (345). Laboratory animal tests reveal liver and blood toxicity (345). Juniper toxicity is a concern. Sickness and death in livestock are recorded if large quantities are ingested. Photosensitization under sunlight exposure can occur in humans who also consume large quantities (Montoya-Cabrera et al. 1996). Monzote et al. (2009) report human toxicity: acute intoxication, gastroenteritis, alterations in nervous system and death in humans for *Chenopodium ambriosoides*.

continued...

Table 11.12 Combinations and toxicities: exploring the judicious use of plants in block 100 with selections from other unusual depositional contexts. In all cases, with the exception of *Allium*, block 100 plants are found in midden 1214, continued.

Selected plants	Cultural contexts	Combinations that include selected plants[a]	Toxic parts	Toxicity factors for selected plants
Chrysothamnus (Asteraceae)	Tower 1008 sealed firepit	Cheno-am, Capparaceae and *Opuntia* seeds, *Artemisia tridentata* achene, leaves, flowering heads and charcoal. *Juniperus osteosperma* twigs.	branches, leaves	Digestive and reproductive problems in grazing animals. Summer brouse could be particularly toxic because of soil conditions (Burrows and Tyrl 2013:231).
Cleome (Capparaceae)	Tower 101 ashpit	Cheno-am, Malvaceae, *Opuntia* seeds (*Zea mays* kernel fragments and other fragmented parts). *Juniperus osteosperma* "stem" fragments, *Pinus* needle fragments.	seeds	Ojiaka and Igwe (2007:735) report low concentrations of lead in flours produced from seeds of *Cleome rutidosperma* (DC)(Fringed spiderflower). Further testing is required to assess lead toxicity after prolonged consumption of seeds.
	Tower 101 firepit	Cheno-am, Cyperaceae, *Juniperus*, many *Mammillaria*, Poaceae seeds and seed fragments. *Zea mays* kernel fragments and other fragmented parts). *Juniperus osteosperma* "stem" fragments, *Pinus* needle fragment.		Crushed fresh *Cleome viscosa* L. plants demonstrate insecticidal effects affecting the development and reproduction of insects on stored crops. Toxicity to humans is not known (Dabire et al. 2008).
	Room 303 corrugated jar	Ground maize, cheno-am, "*Kochia*,"[117] *Juniperus* stem fragments.		
Ephedra (Ephedraceae)	*Cleome* pottery box room 104 firepit	*Atriplex, Cercocarpus, Artemisia tridentata, Juniper* charcoal. This firepit contained an unusual collection of toxic plants.	Branches, twigs, stems	Ephedrine content. Most abundant in the stems can have a similar effect to that of amphetamine (Friel 1977:32). Improper use can lead to nausea, vomiting, increased heart rate and blood pressure, sweating, light-headedness and weakness. Excessive dosing has psychoactive effects, in worse cases can lead to stroke, heart attack, heart conditions and sudden death. *Artemisia*, *Atriplex* and *Juniper* can be toxic.

continued...

[117] Scott and Aasen (1985) identified seeds as *Kochia* in block 300. There are two seeds labeled *Kochia* in the literature, both are from the goosefoot family (Chenopodiaceae). One is *Kochia* now classified as *Bassia* (smotherweed or molly), a native species to Colorado is *Bassia americana* (S. Watson) A.J. Scott (green molly). If the seeds are *Kochia atriplicifolium*, also native to the United States (and Canada), then a different interpretation is possible. *Kochia atriplicifolium* is a synonym of *Cycloloma atriplicifolium* (Spreng.) J.M. Coult. (USDA NRCS 2015) or winged pigweed, the "lightning" and war medicine of the historic Hopi. The seeds of both species are similar in size but differ in shape. Winged pigweed seeds are circular at about 3-5 mm across, *Kochia* are obovate and approximately 2 mm long and 1.5 mm across at the widest point (Martin and Barkley 1961:151-152). Whether these researchers were accounting for *Cycloloma* pigweed type or *Kochia* green molly or smotherweed is unknown. The use of *Kochia* species is documented only for the Navajo as a plant used for

Table 11.12 Combinations and toxicities: exploring the judicious use of plants in block 100 with selections from other unusual depositional contexts. In all cases, with the exception of *Allium*, block 100 plants are found in midden 1214, continued.

Selected plants	Cultural contexts	Combinations that include selected plants[a]	Toxic parts	Toxicity factors for selected plants
Juniperus, Juniperus osteosperma (Cupressaceae) continued...	Tower 101 floor and ashpit kiva 102 ash near deflector and floor midden 103 room 105 beneath HRO 2 kiva 107 east wall niche	Found in all contexts in block 100 and associated with all selected plants with the exception of *Atriplex*.	Seeds, cones, foliage	Severe toxicity from ingestion of a part of a branch in a cat leading to vomiting paraplegia, loss of consciousness, difficulty breathing and respiratory failure (Burrows and Tyrl 2013:398). Herbal remedies using juniper tar or cade oil (*J. oxycedrus*, "common juniper") caused fever, headache, muscle pain, nausea, vomiting, difficulty breathing, gum erosions and kidney failure from consumption of a teaspoon of the tar for kidney stones (Koruk et al. 2005:48). *Juniperus osteosperma* contains an acid metabolite known to cause abortion in grazing animals (Gardner et al. 2010; Johnson et al. 1976).
Malvaceae	Tower 101 ashpit; midden 103 kiva 107 each wall niche	Ashpit: ground maize, fragmented cheno-and *Opuntia* seeds and whole *Cleome* seeds, juniper cone and stem fragments, pine needle fragments. Midden 103 combinations noted under *Ranunculus*.	Leaves, flowers, whole plant	Mallow family species may be toxic to grazing animals and have been linked to a rare neurological problem in horses and cattle when consumption of large amounts of the fresh plant over days or weeks is followed by heavy exercise. This, has in rare cases, led to death of the animal (Burrows and Tyrl 2013:812-813). Gasparetto et al. (2012:184) record toxicity concerns.
Nicotiana (Solanaceae)	Kiva 102 hearth midden 1214	Cheno-am, *Artemisia tridentata* charcoal, *Juniperus osteosperma twig and scale leaves* (kiva hearth). Multiple combinations in midden 1214.	All parts	All parts are poisonous and related to species-specific compounds and causes systemic poisoning in humans (Nelson et al. 2007:6). *Nicotiana tabacum* (cultivated smoking tobacco) is toxic due to nicotine. *Nicotiana glauca* (tree tobacco) is toxic due to anabasine (226). Ingestion of leaves or absorption through the skin from tobacco harvesting or other applications can cause gastrointestinal symptoms, hypertension, sweating, paralysis and in worse cases, coma and death from respiratory failure (226). Furer et al. (2011:50) report two rare cases of poisoning, one leading to death from ingestion of *N. glauca* leaves and poisoning causing paralysis and respiratory failure (resolved) due to a "folk remedy" where a tobacco leaf was applied to a baby's abdomen. Cooked or raw, deaths due to ingestion are recorded.

continued…

venereal disease, for sores and for painting a patient in a healing ceremony (Moerman 1998). As two types of ethnomedicine it is worth considering the significance of either identification.

Table 11.12 Combinations and toxicities: exploring the judicious use of plants in block 100 with selections from other unusual depositional contexts. In all cases, with the exception of *Allium*, block 100 plants are found in midden 1214, continued.

Selected plants	**Cultural contexts**	**Combinations that include selected plants[a]**	**Toxic parts**	**Toxicity factors for selected plants**
Ranunculus (Ranunculaceae)	Midden 103	Ground maize, cheno-am and *Cleome*, Malvaceae, *Mammillaria*, *Physalis*, *Poaceae* seeds and seed fragments and *Juniperus* stem fragments.		Digestive tract irritation is linked to ingestion of *Ranunculus acri* (tall buttercup), *R. sceleratus* (crowfoot, bitter buttercup). *R. repens* (creeping buttercup) is toxic in very large doses (Burrows and Tyrl 2013:1043). Some species cause swelling of nose, lips and face, vomiting, diarrhea, colic and in severe cases, tremours, weakness and seizures in animals (1044). Nelson et al. (2007:6) list *Ranunculus* as a cause of systemic poisoning in humans.

Notes:

[a] plant lists and specimen counts for new samples examined by me are presented in Appendices E and G.

Traditional ethnomedicines, requirements for judicious use, and contemporary pharmacological research

Historically clans and societies are associated with curing of particular diseases and other health problems. Medicines are clearly a keystone category for Pueblo groups. Medicine bundles contained cedar (juniper) and its roots (Parsons 1996 [1939]; Cushing 1920). All ceremonies had a medicine-bowl ritual in the historic period (Parsons 1996 [1939]:870). A few examples of medicine ownership indicate a ceremonial component to curing (from Parsons 1996 [1939]:868-869)(Additional data are presented in chapter twelve):

- Bronchial problems – the War society.
- Deafness – the *Marau* society women's ceremonies (Orayvi).
- Ear pain – Winter solstice society
- "Lightning shock" – Flute society.
- Palsy (?) of face and neck – the *Oaquöl* women's ceremonies.
- Paralysis – *Wuwuchim* men's initiation ceremony and *Marau* women's societies.
- Rheumatism, swellings around the knee and tendons - *Powamuy* society (Walpi).
- Swellings and wounds – Snake societies. Snake medicine (Parsons 1939:416) is "the name of the root medicine of the Hopi Snake society. Beetle medicine used for snakebite is owned by the Snake Dancers at Hopi (416). Beetle remains were found in midden 1214.
- "Twisting sickness" (epilepsy or seizures?) – *Wuwuchim* and *Marau* women's societies.
- Venereal disease - *Marau* and *Lakon* women's societies.
- War medicine (417).
- Bow Priesthood medicines: "yellow medicine," is the name given for Hopi "lightning medicine" or *Cycloloma atriplicifolium*, used as a historical medicine to ensure protection of warriors (Stevenson 1915:84). "This medicine was exclusively in the keeping of the late Nai′uchi and his ceremonial brother, Me′she, who were the earthly representatives of the Gods of War. The secret of its use passed away with their death, as they did not see fit to confide it to others of the Bow Priesthood" (84). "War chiefs become Lightnings, most potent or rain spirits" when they die (170).

Disease, medicine and curing were linked with social organization in the historic period. The toxic and beneficial effects of plants, however, did not arise in the historic period but, as it appears in the case of *Chenopodium*, persisted for centuries. Bear medicine, or rose heath, is an example of medicine and methods of curing and diagnosis. To reiterate this theme first introduced in chapter six, Parsons describes the process:

> The medicine order [of curing societies specifically Zuni, and the Rio Grande Pueblos of Cochiti, Sia and Jemez] is the superior order; but even in it only certain individuals, more particularly the chief, conduct cures. Analogously, in the

> undifferentiated Hopi societies the chiefs only are doctors. The society chief, possibly the medicine chief, will be called upon to cure whatever disease is associated with the society (134). When the one to be "saved" is very ill or wishes to become a member of the society, the society will come in a body to his house, for four nights (Zuni from midnight to dawn), holding their most elaborate ritual, on the conclusive night, or on the fourth night the patient may be taken to the room of the society for the treatment or initiation that all have been four days preparing for. At this time the doctors impersonate the bears from who they get their power, "*they become bears," chewing the bear root which gives them second sight* ... (Parsons 1996 [1939]:135; emphasis added).

Another example of cosmological connections include *Artemisia*. *Artemisia*'s activity as an ethnomedicine covers a variety of effects including as an analgesic and antithelmintic (van Wyk and Wink 2004:55). A historic medicine in the Southwest, Whiting (1939:94) records *Artemisia tridentata* Nutt. (Hopi: *wi:'kwapi*) as medicine associated with the southwest direction on the *Powamuy* altar (Voth 1901:76). Hopi *monáhaña* is identified as *Artemisia canadensis* Mischx. and used as a medicine for headache (41). Fewkes (1896:17; Hough 1897:42) documents a different Hopi word for *Artemisia tridentata* Nutt. (parts unspecified): *napalüña* (*napala*: *apa* meaning an ailing person lying on a mat, *ñahü* meaning "charm"). This species was used in a medicinal infusion for "a person whose ailment is supposed to be in the ilium." Various species of *Artemisia* contain sesquiterpene lactones that are effective in treating gastritis and other digestive problems. Some species are known to contain toxic thujone oils that in high doses or chronic use can be addictive, cause delirium, hallucinations and seizures (van Wyk and Wink 2004:54-55). The use of the plant for medicinal purposes would require knowledge as to dosage.

Medicine within this system encompasses contextual use in healing, war, and social power is important to consider for block 100 in light of its metaphoric content. Recent pharmacological research into a variety of ethnomedicines confirms the pharmacological potential of the species I have identified as "keystone" in block 100. This is particularly true of *Cleome*. Well known as a food and an ingredient in a recipe for black pottery paint, the historic literature says little on the use of *Cleome* as medicine. This does not mean that specialized knowledge of the pharmacological potential of the plant was not known and closely guarded. Moerman (1998) documents the Gosiute and Navajo are using *Cleome* species as medicine although globally its pharmacological potential has been known for centuries. The Navajo report *Cleome* species specifically as a ceremonial medicine. Recent phytochemical analysis demonstrates that the Capparaceae Family, particularly species of *Cleome*, are active pharmaceuticals. It is unlikely that secretly held knowledge would be shared with ethnographers. The description of the Cactus Fraternity sunset dance by Stevenson (1915:96) is illustrative of a similar finding in Cushing's (1920:239-242) *Cactus Picker/Ancient Moon Woman* dance:

> On the return of the Cactus fraternity from the last dance at sunset [dance unspecified], in the plaza, to their fraternity chamber, they are whipped with switches of *ᵗko´shi* (*Opuntia whipplei* Englem.[Rattail cactus])[118] and *pi´la*, willow (*Salix irrorata* Anders.), after which *Polanisia* root and blossoms are chewed and ejected over the bodies of those subjected to the whipping (Stevenson 1915:96).

As a phylogenetic relative of *Cleome, Polanisia* in this application, suggests an analgesic for cactus wounds (in Cushing's narrative, the use of a *tchamahia* would result in injury also). The historic naming tradition for the plant is the same as that of *Cleome* ("hands many seeds"), its similarity in structure notable.

Mock violence in ceremonial practice noted by Ortiz (1972:151) would be a adaptive way to ceremonialize warfare concerns, something that without medicine would be a risky business. Of the 16 taxa of keystone potential in block 100, all are ethnomedicines and fifteen demonstrate pharmacological activity. The need for medicine is demonstrated most poignantly by the human remains in the next section.

The people: skeletal evidence of disease and suffering

I have outlined a brief sketch of Kuckelman and Martin's (2007) findings of the human remains. Based on the data presented, some people suffered from a systemic disease. I suggest that some of the skeletal evidence shares diagnostic characteristics of a variant of treponemal disease. Regardless of its diagnosis, these residents suffered considerable discomfort. A table of ethnomedicines and known pharmacological effects are documented on the following pages (Table 11.13, pp. 444-452 over). A review of the most damaging effects of such a condition confirms the need for medicine.

[118] As tempting as it may be to associate the scientific name (*O. whipplei*) with the "whipping" actions depicted in the reference, the origin of the botanical name is associated with Lieut. A. Whipple, head of the Pacific Railroad Survey (Weber and Wittmann1996:129).

Table 11.13 Traditional medicines and a selection of recent pharmacological studies: block 100 plants.[119]

Species	Traditional medicine	Source	Species	Pharmacological research	Source
***Allium* (Liliaceae)**					
Allium recurvatum, Allium deserticolum	Cathartic, diuretic, ear medicine for curing deafness (original American Southwest groups).	Castetter 1935:15	*Allium cepa* bulb extracts, oils	As a tonic medicine for fatigue, the combined biological effect of the bulb and added starch has been patented.	Ross 2001:12
Allium sativum L.	Expectorant, kidney aid, for the treatment of scurvy, to prevent worms, colic, for asthma, stimulant, ear infections, emetics, eye medicine, analgesic, antirheumatic, for cold and cough (various North American groups).	Moerman 1998:58		A variety of positive effects noted for various conditions in both human and animal testing. Some include antiatherosclerotic, anti-asthmatic effects. Antitumor activity in adults. Diuretic effects (animal testing) Effective on certain bacterias.	Ross 2001: 6-19
	Bulbs used as sedative, blood purifier, expectorant (global).	Ross 2001:3		Antimycobacterial activity (tuberculosis in humans and animals).	Gautam et al. 2007 Newton et al. 2002 Friel 1977:448
	Bronchitis, asthma, chronic diseases of the lungs, whooping cough, tuberculosis (India).	Gautam et al. 2007		Antimycobacterial activity (effective on tuberculosis in humans and animals).	Gautam et al. 2007 Newton et al. 2002 Friel 1977:448
***Artemisia* (Asteraceae)**					
Various species	Antimicrobial, disinfectant, cleansing wash (global).	Moore 1989:104	various species	Inhibits the growth of various bacteria, yeasts and fungal infections.	Lopes-Lutz et al. 2008
Artemisia frigida Willd.	Tea for colds (Zuni) In combination with *Juniperus utahensis* branches as a tea.	Stevenson 1915:42 Robbins et al. 1916:41			
Artemisia canadensis Mischx.	Headache medicine (Hopi).	Hough 1897:41			
Artemisia tridentata Nutt.	Digestive treatment (stronger than *A. filifolia*)(Hopi).	Whiting 1939:94			

continued...

[119] Only a small selection of pharmacological effects is noted. Any plant, herbal or traditional medicine must be used with caution, many toxic effects still remain unknown for particular species, hence the caution noted in the quote the opens this chapter.

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
Atriplex **(Chenopodiaceae)**					
Various species	Fungal infections, bronchitis and diabetes (global)	Jabrane et al. 2011; Keckeis et al. 2000	*Atriplex glauca* L. var. *ifiniensis* (Caball)	Saponin content of the plant has been found to be pharmacologically active in the treatment of cancers, infections and inflammation.	Jabrane et al. 2011; Keckeis et al. 2000
Atriplex canescens	Cure for ant bites when used with *Salvia carnosa* Dougl.(purple sage)(Zuni)	Stevenson 1915:44		Antioxidant effects.	Ksouri et al. 2012; Awaad et al. 2012
Atriplex sp.	"Deer medicine" translated to mean "Mountain sheep-saltbush"(Hopi) but identified as *Salvia carnosa* Dougl., a much valued as a medicine for an epileptic or faint person. Used as a drink or smoked as tobacco.	Whiting 1939:91	*Atriplex glauca* L. var. *infiniensis* (Caball)	Anti-cancer activity is demonstrated in laboratory tests on colon cancer cells.	Awaad et al. 2012:87
Capparaceae					
Cleome lutea Hook.	Ceremonial medicine with tobacco and used to treat ant bites (Navajo).	Moerman 1998:169	*Cleome arabica*	Anticancer activity.	Albarello et al. 2006 Ladhari et al. 2014
Cleome serrulata Pursh	Eye medicine poultice of pounded, soaked leaves (Gosiute). "Good blood" medicine (Ramah Navajo).	Moerman 1998:169	*Cleome gynandra*	Free radical scavenging activity and anti-inflammatory effects on arthritis in nonhuman subjects.	Narendhirakannan et al. 2005 Narendhirakannan et al. 2007
	Gastrointestinal drug: used in an infusion or as a poultice placed on the abdomen (Tewa).	Moerman 1998:169	*Cleome spinosa*	Antioxidant, antimicrobial and analgesic activity.	Albarello et al. 2006 Tsai et al. 2012
Cleome viscosa Linn.	Leaves: boils, earache, headache, ulcers, wounds. Seeds: helminthis infections, convulsions, fever and diarrhea, skin diseases. Roots: cardiac stimulant, diabetes	various sources reported in Mali 2010.	*Cleome viscosa*	Analgesic, psychopharmacological effects, antipyretic and antimicrobial activity. Demonstrated anthelmintic, antimicrobial, analgesic, anti-inflammatory, antipyretic, antidiarrheal, immunomodulatory, gastroprotective, psychopharmacological and hepatoprotective activity	Senthamilselvi et al. 2012. Mali 2010.

continued...

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
Capparaceae continued...					
Polanisia dodecandra ssp. *trachysperma* (Torr. & Gray) Iltis (Capparaceae)	Ceremonial tobacco (Isleta). Switches, roots and blossoms chewed and ejected over whipped dancers in Cactus Fraternity dance (Zuni)[120] No reason given although the use of *Cleome* for inflammation and pain might be a cause?	Moerman 1998:421	*P. dodecandra*, extracts of the whole plant	"remarkable" cytotoxic activity against slow growing tumor cells (*in vitro*) and particularly effective in the treatment of central nervous system cancers, melanoma, leukemia, medulloblastoma, lung cancers, ovarian, colon and renal cancer cells.	Shi et al. 1995
***Chenopodium* (Chenopodiaceae)**					
Chenopodium ambroisioides L.	stem, leaf and whole plant used in the prevention or treatment of cancer in Brazilian ethnomedicine.	de Melo et al. 2011	*Chenopodii ambrosioides* Linn. var. *antheminticum* Gray (American wormseed/Mexican tea)	Notable for its volatile oil used to dispel internal parasites.	Trease 1935:290-291
Chenopodium cornutum Benth. & Hook.	Leaves steeped in water produce a vapour inhaled to cure headache (Zuni).	Stevenson 1915:45	*Chenopodium ambrosioides* L.	A potent antiparasitic agent in traditional medicine where the toxicity/beneficial effects "strongly depend on the proportion" of its major chemical ingredients: ascaridole, carvacrol and caryophyllene oxide.	Montzote et al. 2009:346
				Treats intestinal parasites (a historic non-Native American medicine) that shows demonstrable effects.	Reinhard et al. 1985

continued…

[120] Known by the same name as *Cleome*, "hands many seeds," *Polanisia* (clammyweed)(Capparaceae) looks like *Cleome serrulata* in general growth habit, leaf arrangement, flowering head and seed morphology. When considering the pharmacological effects of *Cleome* species and the uses recorded for *Polanisia*, an alternative explanation for the lack of medicinal uses for *Cleome* could be the result of some confusion over the two plants on the part of the ethnographers, or as likely, that the two plants had special purposes not for general knowledge and not commonly known. The connection with whipped *Cactus* dancers is intriguing for *Polanisia* as pharmacological investigations indicate that *Cleome* (or Capparaceae family genera) demonstrate analgesic, anti-inflammatory and antimicrobial effects. Cushings' (1920) description of the *Cactus Picker* dance reiterated in chapter six is intriguing for this plant.

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
***Chrysothamnus* (Asteraceae)**					
Chrysothamnus nauseosus (Pallas ex Pursh) Britton	Tea for cough syrup and to treat chest pains.	Stubbendieck et al. 2011:147	*Chrysothamnus viscidiflorus* var. *viscidiflorus*	Constituents of the species show anti-cancer activity against human breast cancer cells	Ahmed et al. 2006
	Tea for colds, stomach disorders. Influenza, rheumatism. Steeped flowers and/or leaves as general tonic. Roots and tops for blood in stool.	Duke 1983; Train et al. 1957			
Chrysothamnus parryi ssp. *howardii* (as *Bigelovia douglasii stenophylla* Gray)	A Hopi infusion for bruises and wounds, boils.	Hough 1897:42; Whiting 1939 Moerman 1998:161			
various species	Gastrointestinal medicine (Tewa).	Robbins et al. 1916:56			
	A decoction of wigs for the treatment of toothache and tuberculosis treatment (various Native American groups). Decoction of branches and leaves to treat fevers and syphilis.	Moerman 1998:159-161			
Chrysothamnus and *Pinus edulis*	Twigs and needles for the treatment of syphilis (Zuni, White Mountain Apache).	Moerman 1998:829			
Cyperaceae	*Eleocharis* and *Scirpus* were used for anthelmintic, anti-inflammatory and analgesic properties.	Moerman 1998			
Eleocharis dulcis (Burma.f.) Hensch.	Treatment for infections, infestations and as antibiotic. Corms sometimes used for jaundice (Asia).	Simpson and Inglis (2001)			
Scirpus articulates L. *Scirpus lacustris* L.	Digestive disorders, as a purgative, culms used as an astringent and disorders of the genito-urinary system.	Simpson and Inglis (2001).			

continued...

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
***Ephedra* (Ephedraceae)**					
Ephedra nevadensis S. Wats. and *Ephedra viridis.*	Treatment for syphilis (numerous Native American groups).	Moerman 1998; Niethammer 1974; Stevenson 1915; Whiting 1939	*Ephedra sinica* Stapf.	analgesic, antibacterial (against *Staphylococcus*) and antifungal effects in laboratory tests.	Ross 2001:132-133
Ephedra nevadensis S. Wats.	With the exception of the root the entire plant was made into a tea for the treatment of first stage syphilis disease (Zuni).	Stevenson 1915:49		Dried stem extracts have cough suppressive activity in animal studies.	Ross 2001:133
	Ground into a fine powder for the treatment of syphilis. Root as a poultice for syphilitic ulcers (Pima). Infusions of stems and leaves for syphilis (Hopi, Navajo, White Mountain Apache).	Moerman 1998:406		Cell cultures of extract active on poliovirus 1, Herpes simplex 1 virus and some cytotoxic activity noted using the dried stem with hypertensive activity when using the entire dried plant. Extracts of the root demonstrate hypotensive activity.	Ross 2001:134
	Antipyretic, anti-syphilitic, circulatory stimulant, antihistamine and cough suppressant used for centuries.	Burrows and Tyrl 2013:1248			
Ephedra sinica Stapf.	Treatment of malaria (China).	Ross 2001:131			
Ephedra sp.	Fever, kidney pain and to stop bleeding. Chewed stems used to relieve thirst.	Niethammer 1974:96-97			
***Helianthus* (Compositae/Asteraceae)**					
Helianthus annuus	*Nicotiana* and *Helianthus annuus* seeds are ingredients for snakebite medicine (Zuni).	Stevenson 1915:54		“Expectorant properties.”	Newton et al. 2002:Table 1; 231
	Spider bite (Hopi).	Whiting 1939:97 Fewkes 1892:232		Antimycobacterial activity effective in the treatment of tuberculosis and tuberculosis-related disease.	Onoja and Anaga 2014.
Helianthus sp.	treatment for tuberculosis and other bronchial, laryngeal and pulmonary conditions such as whooping cough (India).			Antidiabetic and antioxidant effects comparable to contemporary pharmacological medicines.	Onoja and Anaga 2014

continued...

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
***Juniperus* (Cupressaceae)**					
Juniperus/Juniperus osteosperma	Twigs and leaves used as drugs in the treatment of arthritis, pain and swelling, steeped in teas or bound on wounds.	Moerman 1998:290-292	*Juniperus communis* L.	dried and powdered roots and aerial parts effective for tuberculosis.	Gordien et al. 2009.
				Essential oil from the needles demonstrates antifungal activity	Cabral et al. 2012.
	Juniper branches are burned as a fumigant to prevent infection.	Allen and Hatfield 2004; Newton et al. 2002; Tilford 1997		Berries: antimycobacterial activity helpful in the treatment of lung diseases such as whooping cough and tuberculosis.	Gautam et al. 2007. Newton et al. 2002.
			Juniperus osteosperma	Reduced microbial activity in clinical trials. Intensive regeneration of skin wounds in animals and reduced healing time for burns.	Johnston, Jr., 2001:47.
	Bronchitis and other chest infections.	Kirtikar and Basu 2004	*Juniperus virginiana*	antibacterial and antifungal activity.	Johnston, Jr. 2001:48.
	Tuberculosis.	McCutcheon et al. 1997	*Juniperus* sp.	*In vitro* studies on berries confirm antimalarial and antibacterial effects.	Samoylenko et al. 2008.
Malvaceae					
Various species	Analgesic for inflammation.	Moerman 1998:334, 767	*Abutilon grandifolium* (Willd.) Sweet (Indian mallow)	inflammatory suppressant and curtails growth of cancer cells that may be protective against cancer, HIV and neurogenerative diseases.	Albarello et al. 2006. Mamadalieva et al. 2014.
	Cold and cough medicine, fumigant, ceremonial medicine, to stop bleeding. Considered a "life medicine." As a treatment for sores the dried plants are pounded to a powder and applied (Navajo).[121]	Moerman 1998:539-540	*Malva rotundifolia* L.	extracts are active against mycobacteria associated with tuberculosis.	Gautam et al. 2007.

continued...

[121] Ethnomedicines described as attributed to the Navajo may have arisen through borrowing from the Hopi, their records provide detail whereas the Hopi records do not. This "absence" of information in Hopi ethnobotanies suggests that *Sphaeralcea* could have been a controlled medicine where knowledge is not shared.

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
Malvaceae continued...					
Malva parviflora	Treatment for blood in the urine, asthma, bronchial conditions due to colds, emphysema and pneumonia. Use during pregnancy "causes abortion" (Karok Elder, J. Peters). In past times a tea was used for tuberculosis.	Peters and Ortiz 2011:109	*M. sylvestris* L.	"Medicinal food" used for a range of medicinal disorders (gastrointestinal, dermatological, urological, respiratory, pain, oral disease). Has antimicrobial activity against 28 strains of *Staphylococcus aureus* and moderate to low activity to *Helicobacter pylori*. Anti-inflammatory. Anticancer activity noted using leaf extract.	Gasparetto et al. 2012.
Sphaeralcea parviflora A. Nels.	chewed and pounded as a gastrointestinal medicine and for broken bones (Hopi).	Moerman 1998:540; Whiting 1939:34			
***Mammillaria* (Cactaceae)**					
Mammillaria grahamii Engelm. var. *grahamii*	Earache, ear infection and deafness.	Moerman 1998:335			
***Mentzelia* (Loaceae)**					
Mentzelia albicaulis	Toothache medicine.	Moerman 1998:671; Whiting 1939:85	*Mentzelia aspera* L. (native to Arizona)	Enhanced antiproliferative activity for some cancers.	de Melo et al. 2011
Mentzelia pumila Torr. & Gray	Powdered root for constipation (Zuni).	Stevenson 1915:57		Anti-inflammatory, antimicrobial and antiproliferative/cytotoxic potential for all species, some for specific tumours.	Ladhari et al. 2014; Senthamilselvi et al. 2012
	Part of a kiva "Cloud tobacco" medicine with the leaves of *Mentzelia multiflora* (Zuni, Hopi).	Stephen 1936:599; Whiting 1939:40	*Nicotiana tabacum* L.	Extracts from the leaves contain natural antioxidants. Free-radical scavenging activity is noted for this plant.	Ru et al. 2012
	Tobacco substitute (Hopi).	Whiting 1939:85			
	Global ethnomedicine.	de Melo et al. 2011			

continued...

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
***Nicotiana* (Solanaceae)**					
Nicotiana tabacum	Fresh and dried leaves applied to skin for boils, ringworm, fungal diseases, wounds ulcers, bruises, sores, coughs, toothache, mouth lesions and more (South America). Infused and ingested along with ayahuasca for hallucinatory effects in shamanic training for Ayahuasca ceremony (Peru).	Ross 2005:272-273			
	"Intoxicant, stimulant, medicine and potent magical agent"(Mayan, Chiapas, Mexico). Referred to as "elder brother," the older brother of lightning and thunder in Mayan cosmology. ("elder brother" references dominate in Pueblo religion).	Groark 2010:8, 21			
	Part of a kiva "Cloud tobacco" recipe that includes the leaves of *Mentzelia multiflora* (Zuni, Hopi).	Stephen 1936:599; Whiting 1939:40			
	Toothache medicine.	Moerman 1998:355			
	Powdered *Nicotiana* and *Cleome* seeds used as a medicine to treat insect bites and painful eruptions, most often as a paste.	Moore 1990:46			
	Nicotiana and *Helianthus annuus* seeds are ingredients for snakebite medicine (Zuni).	Stevenson 1915:54			
***Opuntia* (Cactaceae)**					
Opuntia (prickly pear)	Poultices made of pads for wounds, infections, contusions, bruises. Analgesic effects.	Moore 1989:90	*Opuntia* (prickly pear)	Effective drawing poultices. Pain and inflammation from gum infections and mouth sores are recorded.	Moore 1989:90

continued...

Table 11.13 Traditional medicines and a selection of recent pharmacological effects: block 100 plants, continued.

Species	Traditional medicine	Source	Species	Pharmacological research	Source
***Opuntia* (Cactaceae)** Various species	Flowers of *Opuntia, Mammillaria, Yucca* and *Agave* may have been used as antidotes for anemia.	Reinhard 1992:239-240	*Opuntia* (prickly pear)	antioxidant activity includes diminished growth of prostate, colon, mammary and hepatic cancer cells in laboratory tests.	Harlev et al. 2013
Opuntia whipplei Engelm. & Bigelow	Roots used for diarrhea, either eaten or as a decoction (Hopi).	Whiting 1939:34		clinically shown to lower blood sugar in adult onset diabetes.	Moore 1989:90
***Pinus* (Pinaceae)** *Pinus edulis*	Needles are used as a drug for syphilis. Chewed and swallowed with water. The patient made to perspire "profusely" by wrapping themselves in a heavy blanket to affect a cure or relief. A tea is also made of twigs.	Moerman 1998:161; Stevenson 1915:57-58			
	Powdered pinyon gum used for syphilitic ulcers and as an antiseptic.	Stevenson 1915:57			
Polanisia dodecandra	see Capparaceae		*P. dodecandra*, extracts of the whole plant	"remarkable" cytotoxic activity against slow growing tumor cells (*in vitro*) and particularly effective in the treatment of central nervous system cancers, melanoma, leukemia, medulloblastoma, lung cancers, ovarian, colon and renal cancer cells.	Shi et al. 1995
***Ranunculus* (Ranunculaceae)** *Ranunculus cymbalaria* Pursh	"Navajo medicine" treatment for syphilis (Navajo) ceremonial emetic (Navajo)	Hough 1898 Elmore 1944:96 Vestal 1952:27	Various species	Antimycobacterial activity that may be effective in the treatment of tuberculosis.	Gautam et al. 2007
			R. constantina-politanus, *R. pedatus*	Wound healing, anti-inflammatory	Akkol et al. 2012

The origins of syphilis are contentiously debated but should be understood through emerging research. Syphilis is an "heirloom disease" of yaws that arose with our earliest human ancestors (Harper et al. 2008:para.22) and persists in nonvenereal form around the world. As one of four variants of *Treponema pallidum*, syphilis is the result of a bacterium that causes osteological changes and gummatous lesions such as those causing perforated palate notable in tertiary syphilis and periostitis in infancy and childhood (such as seen in yaws). The nonvenereal variant, yaws, (*Treponema pallidum* ssp. *pertenue*) is more recently considered a subspecies rather than a separate disease (Marden and Ortner 2011:26). In their phylogenetic study of syphilis, Harper et al. (2008) conclude that "venereal syphilis-causing strains originated most recently and were more closely related to yaws-causing strains from South America." Molto et al. (2000:162) argue that the variant, yaws, was the "original treponemal disease" entering North America through Beringia, the other, bejel, entered through a different migration route (163). The cause of transmission is contact with skin ulcers.[122] In their analysis of the skeletal remains of a woman found in a burial room at Pueblo Bonito, Marden and Ortner (2011:28) suggest potential causes of treponematosis at Chaco Canyon.

> Of the four known forms of treponematosis [pinta, another variant is included here, which is though to be eradicated today], the [35-45 year old woman found in the western cluster burial room 326 at Pueblo Bonito] is most consistent with acquired syphilis. Although yaws can cause skeletal lesions in the tertiary stage that are almost identical to those of syphilis, this form is restricted to humid climates [note: yaws has been clinically identified in such varied environments as Scotland and Bosnia (28)] and is most commonly acquired by young children. Endemic syphilis is common in arid, temperate and subtropical climates like that of Chaco Canyon [and Sand Canyon Pueblo] but is also a disease with a childhood age of onset, with a peak prevalence in the first decade of life (Hackett 1983; Aufderheide and Rodrigues-Martin 1998; Meyer et al. 2002), and tertiary lesions usually develop between 2 and 10 years...both yaws and endemic syphilis exhibit cycles of remission and activity in which an initial infection in childhood can reappear later in life.

They go on to note,

> If treponarid was not endemic to pre-Columbian Chaco Canyon, it is just as likely that, lacking immunity to bejel [endemic syphilis] conferred by childhood infection, [the Pueblo Bonito woman] contracted the disease through use of shared food vessels or utensils while passing through an endemic area – or during a visit to the canyon by someone from an endemic area. Exotic goods found in Chaco Canyon that originate as far away as Mexico and California indicate that Chaco was part of an extensive trade network, providing opportunity for infection by outsiders from endemic regions (28).

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[122] Harper and colleagues (2008:para.24) phylogenetic study maps the history of syphilis as follows: *Treponema pallidum* ssp. *pallidum* arose in the "Old World" as a non-venereal infection and spread to the Middle East and Eastern Europe in the form of endemic syphilis (*T. pallidum* ssp. *endemicum* or bejel). It then spread to the Americas as yaws (*T. pallidum* ssp. *pertenue*). Then a *T. pallidum* strain from the Americas was introduced back into the Old World, probably due to European exploration of the Americas, becoming the progenitor of modern syphilis-causing strains.

The woman buried at Chaco Canyon places treponemal disease circa A.D. 890 – A.D. 1150 in New Mexico (Marden and Ortner 2011:21; Windes 2003) indicating a pre-Pueblo III timing and should be considered a potential contributor to the vulnerability of large villages such as Sand Canyon Pueblo. It is these settings wherein larger populations congregate, children play closely together, people share food utensils, that sanitary conditions could be overwhelmed if populations grow too large. The infection rate among young children in close quarters would be expected to contribute to vigorous spread of initial ulcers. A major contributing factor in the spread of treponemal disease is its brevity and visibility of the initial stage of infection, these small and short-lasting ulcerations. Wood (1978:54) lists skeletal evidence with "undisputed syphilitic lesions" for pre-A.D. 1300 Arizona, "pre-Columbian" Pecos Pueblo (Williams 1932), a kind of port of trade in the Ancestral world (Williams 1932). Also present between 1500 B.C. – 800 A.D. in Illinois (Morse 1969) and the Mound Builders population of Ohio and Tennessee (Cole et al. 1955) among others.

Nonvenereal syphilis is a chronic infection that, in the 1970s, was mainly seen in children in many areas around the world (Friel 1977: 651). Periostitis of the long bones is one of the defining characteristics. Some researchers accept nonspecific periostitis as evidence of treponemal infection in archaeological populations (Marden and Ortner 2011; Rothschild and Rothschild 1995). Two other treponemal characteristics include Hutchinson's incisors (pegged teeth) and perforated palate. A review of the salient features of the disease and the skeletal evidence, supports my contention that treponemal disease could be the case for some of the residents of blocks 100 and 1000 at Sand Canyon Pueblo. Skeletal indicators suggestive of treponemal disease are outlined in Table 11.14.

Periostitis in infancy is accepted as evidence of congenital syphilis (Friedman 1958). Transmission occurs during the fetal stage, at birth or occasionally, from breastfeeding (Hollier and Cox 1998). Two syndromes are noted for the congenital infection: symptoms appear either at birth, during the first two years of life or later in childhood. If the disease crossed the placental barrier during pregnancy congenital syphilis is fatal to the fetus or newborn. Early congenital syphilis presents symptoms in the first two years of life, late congenital syphilis presents symptoms near puberty (325). Latency is common with no signs of the disease obvious. Active infection produces inflammation in body organs and tissues appearing by the third to eighth week of life, anemia, enlarged liver and rhinitis (snuffles) are common features of early congenital syphilis. Bone lesions of the humerus and femur may be the earliest skeletal evidence but typically present only in 20 per cent of infants (325). A range of health issues include, but are not limited to, anemia, rhinitis, skin rash, periostitis, and seizure. The only cure is antibiotics (Arnold and Ford-Jones 2000) (Table 11.14, over).

Table 11.14 Human remains with periostitis or other conditions suggestive of treponematosis (systemic disease data from Kuckelman and Martin 2007).

Architectural block	**Human remains occurrence (HRO)**	**General characteristics (sex, age)**	**Indications**
100	HRO 1	infant (1.5-2 years)	slight-moderate periostitis, right femur
100	HRO 2	male (40-45 years)	large perforation on upper palate, left lateral incisor abscess, pegged teeth
100	HRO 3	male (40-45 years)	slight periostitis, both femora
1000	HRO 9	late-term fetus	severe periostitis, tibia
1000	HRO 15	infant (approx. 1 years)	moderate periostitis, tibia
1000	HRO 19	adolescent (12-15 years)	slight periostitis, periosteal reaction on both mandibles and right scapula
1000	HRO 22	child (approx. 8 years)	periosteal reaction, frontal bone

Tramont (2004) lists clinical manifestations of *treponematosis* subsp. *pallidum* indicating that syphilis may have been seen as benign through most of its stages and dormancy is common. In the next active ("secondary") stage the disease spreads throughout the body causing rashes, ulcers, fever, malaise, anorexia and weight loss, arthralgias, headache, meningitis, impaired vision, tinnitus, deafness, kidney and liver inflammation, arthritis, osteitis and periostitis (102). These, too, can seemingly "disappear" within a few weeks or months. If left untreated, late stage leads to more devastating problems: cardiovascular disease, stroke, spinal cord changes, and the above described gummatous lesions. Periostitis may be entirely invisible in late stage syphilis although it is extensive in late stage yaws and endemic syphilis[123] (Rothschild and Rothschild 1995:1406), confusing which variant of the disease is present. Neurological signs are the most commonly associated with late stage subsp. *pallidum* resulting in changes in personality, affect, intellect, insight and judgment (Tramont 2004:104).

Beyond the physical manifestations, the burial room in block 1000 with its infants, children and young adolescent speaks to systemic disease that can occur in utero and is acquired by infants, young children and adolescents. Although poliomyelitis and tuberculosis share similar characteristics (a perforated palate is also known for tuberculosis), further analysis by specialists would be required to rule these out. The 3 year to 5 year infectious period for treponemal disease would increase the probability of passing on the disease through normal day-to-day living such as the sharing of utensils as noted by Marden and Ortner (2011). Rothschild and Rothschild's (2000) assessment of yaws transmuting to syphilis on the Colorado Plateau approximately 2000 years ago further supports a

[123] Endemic syphilis or bejel is non-venereal, affects children and adults typically although not always in warm, arid and rural poor areas. It most affects skin, mucosa and bone. It is passed on through contaminated objects such as eating implements and toys (Wood 1978:51). Rethinking syphilis as a disease of childhood that began in a non-venereal form offers plausible, life-experience explanations for the spread of the disease. Tuberculosis also shares similarities in presentation with syphilis in skeletal remains and was endemic during this period in the Americas (Lambert et al. 2000; Rogers and Waldron 1989).

retrospective recognition of potential treponematosis at Sand Canyon Pueblo. The plant remains and their ethnobotanical uses are evocative in this respect being associated with symptoms such as wounds, inflammation, fever, diarrhea and pain (not to mention deafness) and as definitive treatments for syphilis. Combined with similar evidence at Chaco Canyon, the plant evidence in block 100 is suspect for its pharmacology. Regardless of the systemic disease evident in block 100 and 1000, the plant remains in block 100 have various medicinal properties that would be desirable. Those that are identified as specifically demonstrating antibacterial activity include *Allium* (included here from the pollen analysis done by Scott and Aasen [1985] and Gish [1988, 1990]), *Artemisia, Cleome, Helianthus,* Malvaceae, *Mentzelia, Pinus edulis,* and *Ranunculus*. Other treponemal conditions such as ulcers, pain and other conditions that are part of the spectrum of this illness are outlined in Table 11.15 (p. 458).

<u>Introducing the ideological evidence</u>

I end this chapter with a brief outline of the material culture of SCP that when viewed from the perspective of local theory, links medicine, social organization, and power in block 100. "Medicine" is ubiquitous in Pueblo religion. The gifting of shamanic and curing powers for the mitigation of disease are metaphorically contained within such things as effigies, a "short-form" for a particular kind of knowledge and a particular kind of power. Other ideational clues present apparently only in block 100, are the concentric circle design over the firepit in tower 101, the rectangular pottery box with *Cleome* imagery, and the *Kokopelli* image on the early floor of kiva 108. These manifestations of metaphor are linked to clan and society in the historic period. Sand Canyon Pueblo's ideology is confirmed in architectural configurations, readable by its residents and others that through mythic retrospective, is visible and not incomprehensible today. This "ideational" line of evidence is fully explored in chapter twelve and provides a durable link between block 100 and the D-shaped building with its west and east kivas.

Plant remains as medicines are understood by their association with hearths, middens, tools, technologies, pots, effigies, and seed caches. Even coprolite data can only tell us about consumption, but not the reasons for consumption. Although there is no way to know for certain, there are ways to build a case. Garibaldi and Turner's (2004) cultural keystone species concept provides a structured method by which to assess such evidence and has great potential for the analysis of archaeological material, the ethnoevidence of a culture. A clearer picture of priorities emerges when considering the human remains. The same is true of the artifact record when approached from the perspective of "content," both utilitarian and metaphoric. The significance of certain plants can tell us about how disease and poor health where managed. In the next chapter, the metaphoric content of medicines of block 100 is further supported by social structure and mythic connectionsTable 11.15 summarizes the medicine evidence in block 100.

Table 11.15 Block 100 medicinal toolkit: ethnomedicines and pharmaceuticals.

Disease, illness, symptoms	**Specific conditions**	**Plant medicines**
anemia		*Mammillaria, Opuntia*
antibiotic		Cyperaceae (*Eleocharis*)
antimycobacterial	bacterial infections, tuberculosis	*Allium, Artemisia, Cleome, Helianthus*, Malvaceae, *Mentzelia, Pinus edulis, Ranunculus*
antipyretic		*Allium, Ephedra, Juniperus, Pinus edulis*
cancer, tumours		*Allium. Atriplex, Chenopodium, Ephedra*, Malvaceae, *Mentzelia, Opuntia*
deafness, earache, ear infections		*Allium, Cleome, Mammillaria*
fever		*Cleome, Chrysothamnus, Ephedra*
gastrointestinal		*Artemisia, Cleome, Chrysothamnus,* Cyperaceae (*Scirpus*), Malvaceae (*Sphaeralcea*), *Mentzelia, Opuntia*
infections	ear (and earache)	Malvaceae (*Sphaeralcea*)
infections	fungal	*Allium, Artemisia, Ephedra, Juniperus, Nicotiana*
infections	generalized	*Atriplex,* Cyperaceae (*Eleocharis*), *Nicotiana, Opuntia*
infections	parasitic	*Cleome, Chenopodium,* Cyperaceae (*Eleocharis* and *Scirpus*), *Nicotiana*
inflammation		*Atriplex, Cleome, Polanisia?* Cyperaceae (*Eleocharis* and *Scirpus*), *Juniperus,* Malvaceae, *Mentzelia*
lungs	bronchitis	*Atriplex, Juniperus*
lungs, chronic diseases	tuberculosis, whooping cough, asthma, pneumonia	*Allium, Chrysothamnus, Helianthus, Juniperus,* Malvaceae, *Ranunculus*
lungs, general	coughs, colds	*Artemisia, Chrysothamnus, Ephedra*, Malvaceae
lungs		
pain	analgesic	*Allium, Cleome, Polanisia?* Cyperaceae (*Eleocharis* and *Scirpus*), *Ephedra, Opuntia*
	arthritis	*Juniperus*
	headache	*Artemisia, Chenopodium*
	toothache, mouth lesions	*Chrysothamnus, Mentzelia, Nicotiana, Opuntia*
psychopharmacological	unspecified	*Cleome, Nicotiana*
	neurodegenerative diseases	Malvaceae
seizures	epilepsy, convulsions	*Atriplex? Cleome*
skin diseases	unspecified	*Cleome*
syphilis		*Chrysothamnus, Ephedra, Pinus edulis*
ulcers		*Cleome, Nicotiana, Pinus edulis*
wounds		*Juniperus, Opuntia*

Chapter summary

The cultural keystone species concept developed by Garibaldi and Turner (2004) takes an ecological approach to key symbols first proposed by Ortner (1973) and provides a holistic and culture-centric approach for capturing cultural values not necessarily obvious to the uninitiated, or in some cases, to those embedded in a kind of "ways things are." This can include descendants and researchers. The cultural keystone method privileges culturally specific ideas and values that persist through time reflected at smaller and smaller scales of display. Moving beyond the plant record to understand the plant record using this approach sheds light on a Sand Canyon Pueblo reality that closely mirrors that of social structure in Pueblo society today and one congruent with what is recorded of the historic period.

Chapter 12 A case for clan

> On the basis of ceramic evidence, Hargrave (1932:1) claims Oraibi [sic] has been occupied since at least A.D. 1150. Dendrochronological cutting dates of some Oraibi beams start in the 1350s (Bannister, Robins, and Warren 1967:20-24), but given the paucity of archaeological research, occupation may be considerably earlier than even Hargrave's date.
> (Whiteley 1988:13)

Chapter overview

I use a local theory approach (Whiteley 1998) and privilege Pueblo existentialism as an alternative explanation for the unique configuration of architecture and material remains at Sand Canyon Pueblo that came to light during analysis of sampling effects on plant remains. Underlying themes of traditional Pueblo culture and values paint a picture of what the Sand Canyon Pueblo occupation could have been, one with remarkable congruency with historic Pueblo religion and social organization. Peter Whiteley's research, particularly his 1998 monograph, *Rethinking Hopi Ethnography*, provides the linguistic and analytical clout to fully envision existential themes at Sand Canyon Pueblo. Parsons' (1996 [1939]) reiteration of a Zuni Emergence narrative confirms values and ordering in Pueblo religion that offer new insights into the occupation of Sand Canyon Pueblo and the importance of plants as socially and archaeologically, significant. My case for clans at SCP rests on the legitimacy of Pueblo ethnograhies for key insights. Documented human response to trauma as a result of war, drought, and social upheaval are written on the walls and artifacts of the village, perhaps foreshadowing more elaborated religious practice and social arrangements in Pueblo IV.

Background: moving beyond "species" to understand the archaeobotany

The interpretation of plant remains rests in large part on ethnographic analogy, although ethnographic analogy is often seen as lacking in scientific rigor within Western scientific and legal frameworks. The tentativeness of archaeologists and archaeobotanists to rely on such "unproven" of "unprovable" data sources puts both in an unenviable position of justifying the colonialist past of "western"-indigenous relations in some way, and, relying on what has been traditionally viewed in archaeological research as interpretatively challenging indigenous oral traditions. I maintain that this view of the ethnographically "unprovable" is an artifact of analysis that has had its day. Whiteley (2002:413) recognizes that archaeology as a "science" cannot ignore the "archived histories of oral traditions and cultural modes of encoding the past," stating, "it would be like excavating prehistoric Roman ruins without consulting any Latin sources." Why it has taken so long to acknowledge this bias in "New World" archaeology? The reality seems to suggest that we have not examined how deeply embedded archaeology can be in the idea of "science" and "data" as somehow so rigorous as to override descendant knowledge and data encoded in culture histories. Is it because these ancestors are not ours, "ours" that is, from the perspective of the nonindigenous archaeologist? The passing of the North American Graves Protection and Repatriation Act (NAGPRA) and the landmark court case of rights and title in British Columbia (*Delgamuukw* v. British Columbia 1997) has reinvigorated ethnography and oral tradition as fully legitimate proofs in the courts. The acceptance of oral tradition as clear evidence of cultural affiliation provides archaeologists with a "western" legitimatized source of data with which to interpret archaeological sites; in the case of Sand Canyon Pueblo, some clear consistencies with the historic Pueblos are clear.

In this chapter I outline my case for clan organization by privileging ethnography to explore the deeper meanings of Sand Canyon Pueblo and its material culture. Whiteley (1998:13) makes anthropology a study in *local theory*, using local knowledge in an analysis of "intersubjective and intercultural approximation as the ultimate social goal," a process that embraces many of the ambiguities of the archaeological record. The same can be said then of *a local theory of the artifact*, an intersubjective and intercultural approximation across time. I align my explanation of Sand Canyon Pueblo social organization on this theory, that things can be approximated and the core values, metaphoric significance, and data-rich content of ethnography offer valid insights.

Common threads: common law and cultural values—the legitimacy of ethnographic history as reflective of ancestral evidence

The definition of English Common Law affirms the process of defining and elaborating law—the record of defined concepts of right and wrong that reflect a development and process of encoding culture's core values to manage social concerns. Neglected in the dominant discourse of the status of indigenous people's rights (and histories) until recently, the definition of Common Law is definitive, the process predictable and described as "because it is not written by elected politicians but, rather, by judges, it is also referred to as *unwritten* law or *lex non scripta*" (Duhaime.org; emphasis in original). English Common Law is defined as:

> A body of English law of law which originated with an oral tradition of tribal justice in Britain thousands of years ago and which developed into a unique, cohesive national body of law (the *realm*) developed and set to writing by English judges over time, and which was eventually imported as the law of British colonies throughout the world such as the United States of America (except Louisiana), Canada (except Quebec) and India (Duhaime.org).

What we know today as English "common" law is, therefore, predicated on oral tradition and thousands of years of tribal justice. These English traditions were eventually set down in writing although clearly writing was not a requirement for tens of thousands of years of human history, the

“English” being an amalgam of cultures in the past as in the present. In consequence, the passing of knowledge and cultural expectations to future generations through oral tradition is, as the Courts have accepted, equally hardy as that which is written. This acceptance of oral tradition as reflective of cultural “laws” mitigates five negative themes that persist for archaeological analyses that rely on historic records for insights and proofs of cultural affiliation. These are:

1) Historical writings focused on cultures other than the researcher’s own are too entangled in the dominant cultural view and are therefore biased. Why? Because, it is widely perceived that nonindigenous researchers are unable to grasp the deeper meanings or appreciate social affairs different than their own.
2) Reports of “traditional” lifeways are irrevocably changed through colonialism and its devastating effects and, therefore, are not reliably reflective of ancestral tradition and meaning.
3) Oral tradition is less rigorous than written documentation. Therefore, the oral repetition of cogent themes is not reliable as evidence. (This, of course, throws English oral tradition and English traditional values out the window also).
4) Various narratives and myths appear to be markedly different and cannot be relied on or understood in supportable ways.
5) Oral tradition is embedded within religious concepts (aka core values) that are misunderstood to be fundamentally different to contemporary views. That is, that the cosmological basis on which cultures develop and negotiate human existence are substantially changed in a kind of evolution from an uninformed and naïve (and brutal) past with little inherent value to what is today thought of as the “real” world of fact, logic, and science-based knowledge (and one not so brutal).

All peoples have relied on thousands of years of oral tradition to manage their social problems. Fact, logic, and knowledge gained through testing and practice (“science/research driven”) have not conceptualized in these terms based on prejudicial assumptions applied to indigenous peoples as somehow stumbling on knowledge rather than actively pursuing it. And, brutality persists as it has throughout human history as we have ample evidence this century. The values that developed in our pasts are laid down in our mythic pasts as a kind of first “common law.” The fact that we may not immediately understand the traditions and values of others or, indeed our own past or present (indigenous, nonindigenous, or research-driven), does not preclude us from attempting to understand them. Neither is this ignorance or misunderstanding willful or necessarily an impediment to empathy or appreciation. Much as does anthropological research, archaeological understandings require such analysis to reveal dominant themes—the *key symbols* (Ortner 1973)/*cultural keystones* (Garibaldi and

Turner 2004)—that reflect how people inhabited the world, in our case, through material culture. The remains of which we define as the facts of "occupation." The metaphoric and existential basis on which traditions rest, and artifacts made, can be understood, at least in part, *by* the archaeological record because such things are ultimately part of a *cohesive system of tribal justice and oral tradition.* The Canadian courts agree.

In the case of *Delgamuukw* v. British Columbia (1997), the Supreme Court of Canada confirmed that oral histories and oral testimonies are evidence that share legal status and equal weight with historical documents (Hyslop 2012). Underlying this assertion is that written documents are/were/continue to be considered of higher status (aka more legitimate based on the fact that they were written down) whilst other forms of expression are/were/continue to be, markedly less so. Thus, in *Delgamuukw,* Chief Justice Lamer acknowledged that "*oral histories may be the only credible account of pre-sovereignty title* [land title] *or pre-contact rights*" for the reason that "both embody historical knowledge and express cultural values" (Thom, 2001:4, 5; emphasis added). Oral history reflects the nature of pre-contact *credibility* and also captures the essence of how a culture defined and defines itself through its own "common laws." The ethnographic record documents elements of this credibility. The record holds legitimacy as a proof.

The nature of "common law" shows that its precepts are embedded in notions of metaphysical realms conceived in culture. Its foundations rest in how people see themselves in a world unexplainable. Existential meaning is always culturally cohesive, finding its way into layers and layers of acts, omissions, and judgments. In 1533, Henry VIII of England reworked the Catholic Church in Britain but no one is, or indeed, was, under any illusion he was the ultimate cosmological authority. Believe, or do not believe, transcendental assertions lend power to a cultural complex of values that today underlie original and historic laws. What we call "scientific" evidence is one aspect of evidential legitimacy in this system of managing human concerns. However, to a greater or lesser extent, depending on the government of the time, the ubiquitous "*God* Save the Queen" and "In *God* We Trust" continues to assert influence on how we label ourselves legitimate as Nations. An existential realism underpins how others, too, formulate that legitimacy for themselves (Whiteley 1998). These assertions would have much less power without a sense, acknowledged or not, that something greater than mere politics is at play. As we have repeated proof, our politicians and governing bodies do a woeful job of averting disaster. Thus, the judiciary are required to interject. The implications of such processes are founded in concepts of culture and how legitimacy is perceived. Judges take on the task of reinforcing a value system built on existential ideas of who we are (aligned with an ultimate authority, *God*), and, "they" are (aligned with a mythic past built on "legends" and "stories"). On a deeper level we have sacralized our laws and desacralized the laws of others. Like the reciprocal nature of Pueblo ideology, cultural values both create such concepts and reaffirm the same through conceptions of the Divine (or Divine right) and our place in the cosmic order. Some do a more thorough job than others.

What *Delgamuukw* taught us is that the court has been, and perhaps continues to be, largely unaware of the conditions and content of what is truly the interrelationship between humans and their value systems mapped within cultural conceptions of right and wrong as “gifted” through notions of the transcendental. The Native American Graves Protection and Repatriation Act (NAGPRA) passed on 16 November 1990, expressly affirms that Native American oral tradition, fundamentally based on Native American existentialism, is part of a package of legitimate proofs of ownership for the human remains and grave goods of their ancestors. The United States Congress therefore, accepts Native American patrimony and through this, arguably also accepts the validity and durability of Native American existentialism. Section 7(4) of the Repatriation of Native American remains and objects possessed or controlled by Federal agencies and museums states, in part:

> Native American human remains and funerary objects shall be expeditiously returned where the requesting Indian tribe or Native Hawaiian organization can show cultural affiliation by a preponderance of the evidence based upon *geographical, kinship, biological, archaeological, anthropological, linguistic, folkloric, oral tradition, historical, or other relevant information or expert opinion* (Native American Graves Protection and Repatriation Act AS AMENDED, Federal Historic Preservation Laws: 177; 25 U.S.C. 3005[a4], United States Congress Federal Historic Preservation Laws 1990).

These resources, previously relegated to the legally fanciful, are *proofs* according to both *Delgamuukw* and NAGPRA. The archaeological evidence revealed at the Sand Canyon Pueblo site demonstrates that the occupation is deeply connected with its descendants through the *existential content* of its material remains, in effect becoming such proofs. Interconnected Pueblo warrior themes documented in ethnography, ethnobotany, myth, and narrative can be mapped through architecture, symbolic ideogram, faunal, floral and material remains of the site. This is the integrated evidence that Sand Canyon Pueblo has to offer, connecting a Pueblo III order to that of the historic period. The logical place to begin to understand Sand Canyon Pueblo existentialism is the ethnographic record. Like the majority of villages in the Mesa Verde area of the late 13th century, Sand Canyon Pueblo is a site of trauma. When viewed from the perspective of trauma resolution, the site contains evidence of a set of keystone concepts, ones that logically moved into the historic present through reconfigurations of the past as mythic. These are conditions that continue to assert influence today.

Trauma, cultural continuity and regeneration at Sand Canyon Pueblo

Herman's (1997) description of human responses to catastrophic events that I introduced in chapter seven holds clues as to how Sand Canyon Pueblo people planned to deal with very real concerns of continuous cycles of drought and war, conditions they had experienced transgenerationally before settling in the Mesa Verde region. The nature of the village's reinvention through the development of its particularly unique architecture conforms to typical responses to human trauma and, as such, played a prominent role in how Sand Canyon Pueblo was conceptualized and ultimately configured.

> Traumatic syndromes have basic features in common, the recovery process also follows a common pathway. The fundamental stages of recovery are establishing safety, reconstructing the trauma story, and restoring the connection between survivors and their community (Herman 1997:3).

Even without direct experience of an original trauma, people whose families and ancestors experienced direct trauma seek to recompose cultural and spiritual landscapes to ones of the perceived "safe" or "saf*er*" past. The walls, towers and special buildings at SCP provide clues of trauma experienced before. At Chaco Canyon, violence and "collapse," too, are present. The monumental architecture there speaks of power, knowledge and capability, much as does Sand Canyon Pueblo. Both speak volumes about nature of threat—one of outside, or outside what could be conceived of as the dominant or privileged view. In this, Sand Canyon Pueblo not only looks like the shape of Pueblo Bonito (particularly its west wing/west site-enclosing wall angle), its collapse also mimics Pueblo Bonito. Architecturally, the division between the west and east portions and the alignment of the curve of the west "bow" of the site-enclosing wall mirror the west wall and central division of buildings that separate Pueblo Bonito, the "beautiful house," into different although unequal "halves." At Pueblo Bonito, one "half" is clearly larger than the other, an east-west opposite to SCP where the west half dominates. The wall that separates the twin kivas in the D-shaped building mimics this division, although more evenly—two equal but separate halves. The same effect can be seen at the D-shaped bi-walled bow-like "Sun Temple" at Mesa Verde, another two-kiva D-shaped building. Two separated kivas of equal size are enclosed within a plaza and have centrally aligned indentations in the bi-wall that are suggestive of a metaphoric division (see Fewkes 1916:4, Figure 1). The grammar of such points to a vision of kivas of equal worth, separated but together like twins in a womb, born of the same source but with different but complementary identities.

I suggest that transgenerational trauma is expected from the collapse of the Mesa Verde era of Pueblo prehistory and its effects would conform to typical human responses to such catastrophic events—establishing safety, reconstructing the trauma story and restoring community connections (Herman 1997:3). The archaeological era of Pueblo IV looks like a traumatic response to what was the trauma of Mesa Verde. Like Chaco Canyon, people left and never returned, establishing safety elsewhere. Immediate changes would not include those activities that provide comfort such as religious practice and traditional subsistence. Moving away was certainly helpful in stopping the immediacy of memory. Certainly the values and activities around both food procurement and religion should definitively remain stable or become more ritualized. Here the ethnobotanical record of plant use in history mirrors stability of subsistence (and medicine) before being confirmed in the coprolite evidence (Fry and Hall 1975; Minnis 1989; Reinhard 2006; Sutton and Reinhard 1995), the planting sticks, storage technology, and metate bins. Reorganization of diet would not occur in a landscape where subsistence similarity exists and reorganization of diet would have no positive effects for trauma survivors other than as desperate attempts for food, an interpretation that the archaeological record of Sand Canyon Pueblo does not yet support. A radical change in traditional diet occurs only in the modern era with the availability of grocery stocks (Kuhnlein and Receveur 1996), not as a result of war thus lending additional credence to the ethnobotanical record as a stable source of plant information. The faunal remains of SCP also conforms to typical Pueblo III diet (Reinhard 2006) and traditional practice of historic group-oriented distribution of meat and feasting that is evident in last days at Sand Canyon Pueblo (Driver 2002; Lipe 2002; Muir 1999, 2007; Ortman and Bradley 2002). These findings confirm that the residents subsisted much as their historic descendants had and did not expect the final attack. They were not so resource depleted that moving away was considered by the group that remained. If imminent attack was suspected, the big game fauna in the latest time phrase indicates feasting in preparation, a populace caught off guard, or an attack not expected to be so horrifyingly successful. In their discussion of institutionalized violence in the American Southwest, Martin et al. (2008) make the following observations that resonate at Sand Canyon Pueblo, beyond inferences of resource stress.

> Social violence is, in almost every manifestation, related to ideology, inequality, and power. It serves as an expression of dominance, a proxy for hatred, and a symbol of power and control. By its very nature its meaning is embedded in both biology (damage to corporeal bodies and neurological processes) and culture (producing individual, household, community, and intercommunity reactions). It causes pain that can be physical and psychological, individual and collective. It is prismatic, in that meaning shifts with the perspective of the perpetrator, the victim, the bystander or outsiders. It is difficult to precisely define social violence because definitions are filtered through lived experience, history, and ideology (98).

The progress and effects of trauma indicate that Sand Canyon Pueblo was, indeed, a risk-buffering “safer” world, at least for a time. The rage inflicted on the young, elderly, and infirm was ideological, from within the greater community or from unassociated outsiders. There is no doubt this was a forcible ceding of power. The abandoned effigy in tower 101 does not fit easily with known attackers although the headless bear rock art of the Dolores drainage (Cole 2009:114 Plate 55d) certainly hints that the bear was problematic to someone sometime. The apparent elaboration of religious iconography seen in the rise and visibility of the Katsina Cult in Pueblo IV (Adams 1991) could well be a direct result of the trauma of the 13th century and the need to find community coherence and meaning after such a widespread social disaster.

The same can be said of the configuration of SCP's architecture as mirroring migration narratives. The welcoming of new people into existing villages relies on group ability to mitigate, through ceremony and elaboration, the untenable conditions imposed on human beings, the most basic of which are hunger, disease, and war. These elaborations represent how the process of banished memory includes the reimagining of the trauma story into an original cause that in some way drove the creation of something better. The experience is mapped onto the mythic past aligned with "us" and "others" over time as a direct effect of banished and, I would include, "personal" memory. The archaeological record reflects banished memory and is written in the architecture and iconography.

Orayvi village as an ethnographic analogy

The quote that opens this chapter indicates a time depth of occupation of Orayvi village that puts its earliest known occupation within twenty years of the waning Classic Bonito phase (A.D. 1020 to 1120) in Chaco Canyon (Cordell 1997:191-192) and early Pueblo III in the Mesa Verde region (Lipe and Varien 1999a, 1999b). Sand Canyon Pueblo people and the people of Mesa Verde came from, and/or dispersed and resettled to, villages like Orayvi. Ultimately they brought their knowledge and abilities to the Mesa Verde region and then from Mesa Verde to elsewhere. The importance of Oravyi for the archaeological analysis of ancestral sites is recognized by Cameron (1992) and Whiteley (2004) who note that Orayvi's social organization, architecture, ideological rifts, and behavioural transitions can be mapped onto ancestral villages and understood through ethnographic analysis. Architectural changes noted for Orayvi in its periods of upheaval are similarly displayed at Sand Canyon Pueblo. These are manifested in the disuse of some buildings; the dismantlement and the re-use of others lending credence to the re-use and dis-use of Sand Canyon Pueblo rooms and kivas as a reflection of village reconfiguration due to ideological rifts. Orayvi has weathered at least two disordered episodes, one mythologized as the ceding of power by the Bow Clan and attributed to corruption in the Pueblo Third World; and, in more recent history, the collapse of the Bow Clan in terms of both power and presence (Whiteley 1998). In the most recent incidence the social order was reconfigured as the direct result of a prominent Bow Clan associate's conversion to the Mennonite religion in the early decades of the 20th century (Whiteley 1998).

Ceding power in the face of behaviour incongruent with Pueblo values is a feature of Emergence narratives. The path to a Pueblo "good life," is, as in any culture, dependent on behaviour that conforms to a value system that permeates all things in obvious and less obvious ways. To understand something of that value system I revisit Parsons' reiteration of Zuni Emergence to underscore the significance of the Bear Clan in Pueblo history. The connection between Bear Clan leaders and the iconic War Brothers provides a basis for my interpretation of similar ordering at Sand Canyon Pueblo.

Re-envisioning Sand Canyon Pueblo

The evidence

The most interpretatively generative finding at Sand Canyon Pueblo is the effigy of tower 101. The most significant new information is not the effects of archaeobotanical sampling *per se* but the identification of the effigy *as a bear*. It matches in form and characteristics with the Bear image on the west wall of the Warriors' Room at Walpi Pueblo on the Hopi mesas and identifies the residents of the kiva suite in Sand Canyon Pueblo's block 100 as somehow associated with the culturally significant metaphoric content of a Pueblo "bear." The content of a Pueblo "bear" is inextricably linked to plants and plant power. The "bear" is, in effect, archaeobotanical.

The Bear Clan has a deep history that links its power to that of the mythic War Brother twins and "Bear medicine," the origins of which are remembered and reinforced through oral tradition. Further links can be made from Fewkes' (1902) redrawing of the murals at Walpi. In addition to the bear image on the west wall, the wolf image on the east wall, a painting of concentric circle accompany an image of "wild-cat" on the south wall. The wolf is accompanied by a painting of the sun figure with four pairs of feathers oriented to each cardinal direction (486). Although apparently unique to the Warriors' Room at Walpi, they are not unique to Pueblo culture. Sun and concentric circle imagery, warriors and twins are represented in rock art across the Four Corners (see Cole 2009, Schaafsma 1965).[124] When viewed through an ethnographic lens, these images are symbolically connected to social standing the basis of which is the sun or Sun Father of Pueblo religion.

Effigies, like imagery, are readable. The Sand Canyon Pueblo bear is no exception. Cushing notes that Zuni "fetishes" were, for the most part, connected with "animal gods, and principally to the

[124] In the Warrior's Room mural at Walpi the Sun is positioned to the right of the east animal (Wolf), a concentric circles with a central star is located below the bear figure on the west wall. The positioning of the sun and circle images is specific to these particular animal motifs in the reproduction. The concentric circle design above the firepit in tower 101 at Sand Canyon Pueblo is intriguing in a room that also contained an effigy of a bear. Their close alignment and narrative histories indicate that the bear image has metaphoric connection with the concentric circle, and the wolf image similarly associated with the Sun. In the following discussion, the Sun Father, War Brother Twins, and the ideational associations of the sun, warriors, war priests, and the D-shaped building such connections become clear.

prey gods" such as bear, wolf, wildcat and mountain lion (1883 in Green 1979:197), the same figures as drawn on the walls at Walpi. Cushing explains that, "a highly prized class of fetiches [sic] are...those which are elaborately carved, but show evidence, in their polish and dark patina, of great antiquity. They are either such as have been found by the Zuñis [sic] about pueblos formerly inhabited by their ancestors or are tribal possessions which have been handed down from generation to generation" (198).[125] Bear effigies and the bear "trope" is a significant feature of Hopi, Zuni, Keres, Jemez, Tewa, Isleta, and Taos pueblos (Parsons 1996 [1939]: Table 2). The Bear as curer is noted specifically for Keres, Tewa, and Isleta in this source. The Bear and its link to the Bear Clan is directional, associated with the west direction, the movement of the sun towards sunset, the Younger of the War Brother Twins and powerful medicine (Parsons 1996 [1939]; Stephens 1936). All are founded on transformative and reciprocal power acted out within and through these relationships.[126]

Emergence narratives confirm that reciprocity underlies Pueblo ideology and is deeply connected to the Sun Father, the mythic Twins, and the notion of valuable contributions for the betterment of all that underpins the acceptance of new people into existing villages. All draw on, and gift, the power of plants and the potency of particular animals in the mitigation of human concerns. The cohesiveness of "medicine" within this system cannot be understated. I have shown in the previous chapter that a medical toolkit was in use at Sand Canyon Pueblo. Medicines permeate ethnographic histories and are categorized, owned, and bestowed in very particular ways. Medicine is transformative through both diagnosis and curing, but it is also conceptualized as power—the power to bring rains and the power to assist (Parsons 1996 [1939]). Particularly powerful people hold secret knowledge of medicine. Accessing this invisible realm of influence requires alliances with and between existential beings and their chosen human counterparts. To see such evidence in archaeological sites requires an analysis of the nature of Pueblo existentialism (Whiteley 1998; 2004) and how existential organization is represented. I outline some key plants conceptualized as medicine and used in Pueblo history to demonstrate a hierarchy of knowledge and ownership (Table 12.1). Medicine is not only owned but scales down into categories of social standing.

[125] A slightly different association between directions and animal ideograms is recorded by Cushing who identifies the six species of Zuni prey animals as Mountain lion (North), Bear (West), Badger (South), White Wolf (East), Eagle (Upper) and Prey Mole (Lower). Each then is divided into six categories based on colour: Mountain lion (Yellow) is primary god of the North but has representatives in other cardinal directions. His "younger brother," the Blue Mountain Lion is associated with the West, other younger brothers are the Red mountain lion in the south and "the White" in the east. The Upper is "the Spotted" and the Lower is "the Black" (1883, from notes "2"). The bear, however, is consistently associated with the west direction.

[126] Alexander Stephen's *Hopi Journals* written between 1881-1894 record his "cure" of what is inferred to be tuberculosis by a medical specialist named Yellow Bear, incorporating a metaphoric west "colour" and animal into the naming of this individual (Parsons 1996 [1936]:XXIV).

Medicine, myth and threat mitigation

As I have described in chapter ten, medicine is a cultural keystone in Pueblo society. In the historic literature, there are two obvious categories of curing medicine consisting of “clan medicines” and “medicines for all people” (Stevenson 1915; Whiting 1939). The difference is in access to specific medicinal knowledge and proper application. Clan medicines are an elevated phenomena. In the late 1800s, Cushing (1882 in Green 1979: 96) identified four classes of Zuni social organization, some singled out by ownership of medicine. The first, the “Martial class,” is the most secret and belongs to the “Priests of the Bow.” The second, “Ecclesiastical,” is owned by “*Shi-wa-ni-kwe* or Society of Priests” and considered sacred. The third, “Medical,” consists of cactus, knife orders, “Bearers of the Wand” (previously identified as Bear and Crane clans [Cushing 1920:29-30]). This group includes such divisions as, but is not limited to “fire orders” that treat inflammation and “lesser fire and insect orders” that treat burns, ulcers, cancer and parasitic infections. The fourth class, “Hunters,” is of the “blood or coyote order” (Cushing 1882 in Green 1979:96).

A particularly intriguing medicine is *Cycloloma atriplicifolium* (“yellow/lightning medicine” gifted by the grandmother of the Gods of War [Spider Grandmother] by casting “a peculiar yellow light” [Table 12.1, pp. 470-471, see also p. 441].[127] The yellowness of the light links yellow foxes, coyotes, and “putting up the sun” by Bow priests (Whiteley 1998). The congruency of colour, directional cues, animals, plants, and mythic and worldly leaders permeates the entire scheme. The essential nature of “medicine” is not only one of cures, but also of associations of ownership, knowledge, status and influence. Medicine is a mitigating factor in conflict and acceptance, in war and enactments of war.

Firmly anchoring medicine as an analytical category is challenging as I demonstrated in chapter ten. Beyond the obvious taphonomic effects imposed on archaeobotanical remains, medicine is about consumption and in many cases consumption is ethnographically associated with food. The record hints at one of the reasons this might be so. Plant foods are ceremonially democratic, although preparatory activities associated with societies and clans were historically contextually specific, making the towers of Sand Canyon Pueblo of particular archaeobotanical interest. Rooms (the Warrior Room at Walpi is an example) and ceremonial kivas were contextually ceremonial and thus, potentially linked with medicine. The bear effigy and the tower are quite simply “containers” for such things.

[127] Evidence of *Cycloloma atriplicifolium* seeds is documented for great kiva peripheral room 805 and inferred by me based on contents of a vessel in room 303 in latest occupation contexts.

Table 12.1 Clan medicines: a selection of historically "owned" medicinal and sacred plants. With the exception of botanical names, italics are taken directly from the source document.

Scientific name	Common name	Indigenous name	Translation	Ownership	Description	Source
Artemisia frigida Willd.	Sagebrush	*To'shoeha'chikia* [Zuni]	*wild sage*	Corn Maidens	*Medicine of the Corn Maidens*. *Sprigs of the plant, together with ears of corn, are attached to decorated tablets carried in the hands of certain female dancers in the drama of "The Coming of the Corn Maiden." At planting time the corn is sprinkled with twigs of artemisia* [sic] *dipped in water,"that it may grow in abundance."*	Stevenson 1915:87
Chaetopappa ericoides Roth.	Rose heath			*Bear medicine* [Hopi]	[the root] *Used by all curing societies* [Zuni], *induces a trancelike state in the doctor during which he can see the witch causing the sickness.*	Parsons 1939:414
Cycloloma atriplicifolium (Spreng.) Coulter	Winged pigweed	*A'kwa tupt'sine* [Zuni]	*yellow medicine*	*Grandmother of the Gods of War* [Spider grandmother]	[Spider grandmother] *gave it to them with instructions that when near the enemy they should bit off some of the blossoms of the plant and chew them, ejecting the mass into their hands and rubbing the hands well together. As soon as the Gods of War had done this a peculiar yellow light spread over the world, preventing the enemy from seeing how to aim their arrows truly. This medicine was exclusively in the keeping of the late Nai'uchi and his ceremonial brother, Me'she, who were the earthly representatives of the Gods of War.*[128] *The secret of its use passed away with their death, as they did not see fit to confide it to others of the Bow Priesthood.*	Stevenson 1915:84
		masi'ta'ʒngwa or *koto'ki* [Hopi]			*Used medicinally for fever, rheumatism, headache, and lightning sickness. The latter results from breathing the "smell of lightning," which, it is said, is similar to the smell of this plant. The seeds are reported to produce a pink dye.* The plant shares the same name as *Reverchonia arenaria* A. Gray (sand reverchonia) or Hopi *masi'ta'ʒngwa* used for rheumatism and as an emetic.	Whiting 1939
Lithospermum linearifolium Goldie	Puccoon	*Kwi'minne kwin'na* [Zuni]	*Black root*	*Priesthood of the Bow*	*In time of war* [the leaves] *with their tips pointing downward, were often bound on the arrow-shaft, close to the point, and entirely obscured by the sinew wrapping. The Zuñi* [sic] *claim that this leaf is so deadly poisonous that an arrow thus prepared will cause the immediate death of one pierced by it. Used for this purpose, the plant belongs solely to the Priesthood of the Bow.*	Stevenson 1915:85

continued...

[128] Presumably these names belonged to important and initiated individuals at Zuni (see also Ferguson et al. 1996).

Table 12.1 Historically "owned" medicinal and sacred plants. With the exception of botanical names, italics are direct from source, continued.

Scientific name	Common name	Indigenous name	Translation	Ownership	Description	Source
Lycium pallidum Miers.	"tomatilla" [wolfberry]	*Kiaʹpuli* [Zuni]	*"Water fall down" so named because the rains cause many of the berries to fall from the plant*	Elder and younger Bow Priests	*Sacred to the Bow Priesthood... Elder and younger Bow Priests watch the plant, constantly sprinkling meal* [presumably corn meal] *at its base until the berries appear, and then the entire plant is sprinkled with meal* and prayers for a good peach crop [Zuni]. [Hopi] the shrub plays a role in the *Niʹman* ceremony (the Katsina "home going" ceremony in July).	Stevenson 1915:94 Whiting 1939:44
Machaeranthera glabeela Greene ex Rydb.	Hoary tansyaster	*Uʹtea oʹkia* [Zuni]	*Flower woman*	Elder and younger Bow Priest medicine	The Zuni name references the naming of the plant that purports to render enemies as *weak and helpless as women.* Before going to war, elder and young brother Bow Priests *gave a pinch of the powder to each warrior, who placed it in his mouth and, ejecting it into his hands, rubbed them over his face, arms, and body, so that if the enemy's arrows should fly thick about him they could not reach him.*	Stevenson 1915:56, 94
Phaseolus angustissimus A. Gray	"wild bean"	*Haʹtsumewe,* *Aʹhayuta, Aʹhayuta an kwiʹminne* [Zuni]	*strong leaf* referencing the *strength of the people who have been treated with the plant.*	*Gods of War* [mythic Elder and Younger Brother]	If a warrior applies *Aʹhayuta's root* medicine to an infant, this ensures that the child will be brave and unafraid of the enemy. The warrior chews the powdered root and mixes it with crushed leaves and blossoms of the plant and rubs it on the body of the infant who also receives crushed blossoms to eat. *Aʹhayuta* is the name given to the Gods of War during peacetimes, the medicine is known as *Aʹhayuta's root.*	Stevenson 1915:85
Populus angustifolia James	Narrow-leaf cottonwood	*Piʹla oʹtsi* [Zuni]	*Cottonwood man* referencing the *male tree*	*Koʹtikili* (*mythological fraternity)*	*The slender twigs are employed by all members of this Koʹtikili...in preparing offerings to the Sun Father, the Moon Mother, and the ancestral gods.*	Stevenson 1915:96
Salvia carnosa Dougl.	Sage	*Paʹngkitsvi* [Hopi]		*a Deer medicine*	*Seen only in a canyon near the Winslow road south of the Hopi Reservation. Much valued as a medicine for an epileptic or faint person. It may be administered as a drink, or prepared as is tobacco, and its smoke blown into the face of the patient.*	Whiting 1939:91
Thelypodium wrightii A. Gray	Wright's thelypody	*Haʹkoʹlokta noʹwe aʹwa aʹkwawe* [Zuni]	*Sandhill-crane beans all medicine*	Sandhill Crane clan	The abundance of seeds are seen to influence the bean crop. They *are crushed by women of the Sandhill Crane clan, and mixed with beans that are to be planted* to assure similar abundance.	Stevenson 1915:95

Mobley-Tanaka (1997) situates such spaces as male-dominated (see footnote 32, p. 135), the mealing-rooms the purview of women. Although acted out in plaza dances and ceremony, the mealing function is both ontological and phenomenological, the female role taken on by male impersonators in ceremony today. The preparation for both occurs in the rooms and ceremonial kivas of the historic and contemporary Pueblos. The experience of grinding corn takes on mystical qualities because the very nature of corn is both physical and cosmological sustenance. Taken to its logical conclusion the moving metates of Sand Canyon Pueblo tell us something about roles, making food, and a shifting focus. The maize "trails" to altars and rooms documented in the ethnographic record bring to bear the significance of maize as cosmological and, as research fragments, worthy of additional consideration in archaeological sites. The importance of individual plant types (genera, species, parts and fragments) resides in their significance to daily and ritual life, both cosmological and seasonal in content, acted out in seasonally specific spaces and places. The relational interplay is incorporated into naming conventions and honoured in ceremony (Appendix B).[129] Some plants, more potent than others in some way, show up as clan names and as beings of the spirit world returned and acted out by dancers and Katsinas. Such evidence can be seen in the description of the historic Cactus Dance (Cushing 1920) and the seriousness of ceremonial "mock violence" (Ortiz 1972). The same can be said of the artifact class, "*tchamahia*," a mock weapon associated with what could reasonably be described as the dangers of cactus picking in the face of injurious spines and the requirement of medicine in the aftereffects of wrestling with such a hard to harvest resource. The study of archaeological plants, and thereby their place in the lives of people, can be only understood within the

[129] Durkheim (1915:119) explored the use of totemic decorations as a form of elevating society as divine rather than representing a Divine power arguing that, "the totem is not merely a name and an emblem. It is in the course of the religious ceremonies that they are employed; they are a part of the liturgy; so while the totem is a collective label, it also has a religious character. In fact, it is in the connection with it, that things are classified as sacred or profane. It is the very type of sacred thing." Again, the question of "who" is divine comes into play. The bear effigy hints at an alliance with divine, not a creation of a group or society which claims divinity. It is a type of democratic thing. Bear medicine is gifted by bear shamans, their power, however, is inextricably linked to a Divinity or collective Divinity (the Sun, the Warrior Twins, and Spider Grandmother). Daily life does not equate with profane but rather with religious ideology about "how to live," a formalized but often unconscious guarding of our humanity imposed through cultural values of "the good life" as expressed by Montaigne (a particularly illuminating passage describes the horror of civilians as victims of the mob, famine, and religious massacres in France ca. A.D. 1500 [Bakewell 2011:205-221]). Sand Canyon was such a place, the plants represent a fundamental part of daily life but with archeological and architectural evidence of historical religious liturgical significance: "while generations change, it remains the same; it [the totem] is a permanent element of social life" (Durkheim 1915:221). This is the true dilemma of interpreting shifts and changes in plant use (and religious ideology) for Ancestral Pueblo with its links to a descendant culture defined by a type of democratic sharing at the household level, in the plaza, and in liturgy. Here again, the cultural significance and underlying secret knowledge associated with Zuni *Ahayu:da* is emblematic of a greater spiritual reality, one revered and associated but not one of an elevated divine "society." The architecture of Sand Canyon Pueblo clearly incorporated both defensive and spiritual themes much as Muir (1999, 2007) suggests for the faunal remains. These same themes persist in the architecture of the mesa top villages of the Hopi and the ceremonial importance of plants and animals.

"webs of [social] significance" occupied by plants, "the analysis of it [in this case, archaeology] is to be therefore not an experimental science in search of law but an interpretive one in search of meaning" (Geertz 1973:5). The effigy at Sand Canyon Pueblo occupies this web, one that is inextricably linked to the power of plants.

Sand Canyon Pueblo is unique in the region for its construction and elaboration, clearly demonstrating how people managed and attempted to control trauma under threat of continuing violence. Public structures such as the D-shaped building and the great kiva clearly played a pivotal role, at least for a time. How people responded to life at SCP can be seen through remodeling episodes that included refurbishing the D-shaped building walls and floors and later included the replastering of floors, in the case of kiva 108, extinguishing imagery of a *Kokopelli* figure and the sealing over of firepits in tower room 1008. Plant use is largely stable, however, based on the record as it is today. I confirm that the same plants present in earliest deposits are present in latest. Although leaving Sand Canyon Pueblo and setting down roots elsewhere would be an effective coping strategy in the face of declines in resources; the ecological landscapes to which people migrated are similar, it is still arid, there are still droughts, and there are limits. The resource availability across the Four Corners shares similar "Mesa Verde" environmental conditions. In this respect the ethnobotanical record and the validity of using a local theory for meaningful insights, demonstrate durability of use in similar ecological environments. Proofs that are further reinforced by the durability of traditional Pueblo values in the face of trauma and resettlement, in what changes and what typically does not.

As described in chapter six, "Bear medicine," a purported narcotic plant root, belongs to the Bear Clan (owned by Flint and Fire societies at Zuni in the historic period [Parsons 1996 (1939:189)]).[130] The plant was critical for the transformation of Bear Clan shamans into the Bear, a transformation derived from the mythic bear at Shiprock and his encounter with the Elder War Brother twin (189). The effects of the root permit the shaman to see as the bear does, that is, somewhat surreptitiously. This "looking" is a kind of "second sight" not accessible to the uninitiated and sets the Bear Clan apart in the ability to diagnose illness (414). In Parsons' record, the diagnosis of physical discomfort, illness, disease, psychological conditions and witchcraft is possible through this transformation (135). Such "medicines" play a role, too, in the historic acceptance of new people to Hopi villages. This welcoming was predicated on newcomers' ability to demonstrate benefit to village life through ceremony (Whiteley 1998:113-114). The ability to capture the essence of transcendental power is laid down in myth. To bring rain is the most obviously desirable

[130] The Hopi Fire society/clan is *Kookop*, an important group with mythic connections with the Elder Warrior Brother (Whiteley 1998). Whiting (1939:46) places *Kookop* (spelled *Kokof*) in the Fire-Coyote Phratry, its name derived from Juniper (*Juniperus utahensis*). The connection of *Kookop* with Coyote, the yellow dawn light of the Bow Priests, and fox-skins are intriguing in this regard.

transformation in the harsh and unpredictable climatic conditions of the Southwest. The spectre of war was of equal concern. All contribute to a complex of cultural associations that aim to buffer risk, both internal and external. The same is true for ancestral villages. Adler (2002) writes of communities such as Sand Canyon Pueblo as,

> risk-buffering organizations, particularly among food-producing peoples such as those living in the ancestral and historic Pueblo worlds are not simply aggregates of interacting people; they are also aggregates of shared risks, interdependence, and identities. The community functions to justify, reproduce, and defend the sets of social relationships that underlie individual, household, and corporate (multihousehold) group access to productive resources across the local landscape (29-30).

Entities such as effigies are material correlates of a set of risk-buffering strategies that set people apart as aligned with an identity vested in notions of power over risk and as such, legitimacy. Such symbolic representations assert social status and mitigate competitive risks between “in” and “out” groups by continually re-enforcing a recognizable identity. To do this effectively, “identity” and shared (or imposed) cultural values are compelling and accepted as *real* because they are deemed to be cosmological. The final welcoming of the Badger Clan by the Bear Clan leader in mythic times at Orayvi, celebrated in the *Patsavu* ceremony, demonstrates existential underpinnings of Pueblo social organization and power.

> The ascent of the katsinam (katsinas) into Orayvi in part reenacts the original arrival of the Badger clan [in mythic times]. Each Orayvi clan, having completed its migrations undertaken after emergence from the “third” world below, had to seek entry to the village from the first arrivals, the Bear clan, and in particular their leader, the *Kikmongwi*, “village chief.” Each clan had to demonstrate special ritual or other abilities before the *Kikmongwi* would accept them. At first the Badger clan, whose skills pertained to medicine and seed-fertility, were refused admission and went off to live at Tuuwanasavi (“earth-center place”), a few miles south in the Orayvi Valley. Finally, the Kikmongwi decided he needed their skills, and went four times (the archetypal number in Hopi sacred narrative, but, in this case, also because the Badgers were miffed by their earlier rejection) to persuade them to move into the village. To mark the significance of the event, the Badger clan entered Orayvi dressed as katsinam, along the same route from below that is retraced in the *Patsavu* ritual (Whiteley 1998:114).

In this narration, the Bear leader initially refuses entry but later changes his mind. He repeatedly petitions by wisely acknowledging the Badger Clan’s abilities and social relevance (“medicine” and “seed-fertility”). Through these efforts the Badger Clan is restored and the *Patsavu* celebration encompasses both the original error (the Bear Clan leader’s misjudgment) and the correctness and value of the Badger Clan’s return. Surreptitiously, the ceremony also identifies the Bear leader as acting appropriately by the significance of the number of petitions through aligning the correctness of the action with existential authority (Whiteley 1998:114). These characteristics give status to both clans. A bear effigy, then, represents what it means to be "Bear" in oral tradition. The bear effigy is, in effect, a "densely laconic narrative" (Whiteley 1998:114) and container of knowledge for, and of, the Bear Clan and its elevated relationship in social standing due to its unique position within the transcendental order. A position gifted through a cosmological act of transformation.

Ortman and Bradley's (2002) description of Sand Canyon Pueblo as "the container in the center" refers to its position as a major hub based on large and imposing communal construction projects such as the site-enclosing wall, the great kiva, and the D-shaped building. These architectural displays suggest a compelling influence resided inside with its message obvious to others outside its enclosing walls. Clans achieve similar goals, functioning to justify, reproduce and defend relationships. They identify and define an ethos of knowledge, leadership, and compelling reasons for social integration. To be such requires an acceptance of the underlying existential nature of the social order. The same would apply to ancestral populations—acceptance of a *Sand Canyon Pueblo* ideology across a large area to distinguish this village as particularly effective in managing the concerns of its residents and the greater community, or at least significant as an outward display of such ideas. In this respect Sand Canyon Pueblo is a "container" distinguished by an apparent alliance with transformative power such as that of the rich and earlier Pueblo Bonito. Similarly, the association between identity and "medicine" documented in the historic period demonstrates identity with spiritual connections, powerful abilities and social standing. How the "bear" achieved its unique position is described in a Zuni Emergence narrative.

The "*standing bear*:" trauma and transformation in Emergence narrative

Mythic beings access the capabilities and knowledge of particularly talented humans beings in order to achieve their goals. The process is gifted back. Through this perceived interdependency, people are aided in their ability to manifest metaphysical power through the proper channels. In Parsons' reiteration of the Zuni's Elder Twin Brother's accident with the Bear at Shiprock[131] that I label here as a referential strategy, the *standing bear* narrative, the existential reciprocity principle that supports Pueblo life is illustrated. The key figures are the Sun Father, the Younger and Elder War Brothers (sons of the Sun Father and grandchildren of Spider Grandmother), the Bear Clan, the Deer Clan, Coyote and Corn clansmen. Zuni women provide the sacred sustenance (ground maize) that lays out the "road" and prompts the interaction with the Bear resulting in the initiation of a relationship between the Elder and Younger Brother, Bear and Deer clans. I have included here only limited selections from the text. The entire narrative is found in Parsons (1996 [1939]:218-236). The twins

[131] Shiprock, New Mexico, is approximately 64 km from Sand Canyon Pueblo as the crow flies.

are referenced as "two children (of the Sun Father)," "War chiefs" and *Ahayuta*. Bracketed italics are comments from me; bracketed un-italized notes are from Parsons.

> In this world there was no one at all. Always Sun came up; always he went in. No one in the morning gave him sacred meal; no one gave him prayer-sticks; it was very lonely. He said to his two children, 'You will go into the fourth womb. Your fathers, your mothers, [the rain and seed fetishes and the fetishes of the *Thle'wekwe* winter society],[132] all society chiefs, society criers, society war chiefs, you will bring out yonder into the light of your Sun father.'
>
> Laying their lightning arrow across their rainbow bow, they drew it. Drawing it and shooting down, they entered. ... With dry brush and grass and their bow on top[133]they kindled a fire [*in its light the twins saw that the people were slimy, with webbed hands and tails.*] ... There were no houses; they *[the people]* just lived in burrows in the ground. The people said, 'Why have you come?' – 'Our Father Sun has sent us in for you people to come out into the daylight of your Sun father. Our Father Sun knows everything, but none gives him prayer-sticks or sacred meal or shell' (Parsons 1996 [1939]:218).
>
> ...So all the people got ready and took all their *eʔleteliwe* ['What we live by,' referring to the *eto·we* or fetishes for rain, snow, and seeds]...When they all came out they saw Father Sun, and they shut their eyes because it was so bright (219).
>
> *Over the course of time the War Brothers lead the people through their migrations with periods of stopping (every four years). The people gained useful things although had to endure the death and killing of children and other trauma. The death of the children is explained as dying but yet living because the children go to the place of Emergence awaiting their parents' return. The recommendation to* 'hold your children tight' (222) *is particularly poignant and clearly tragic at Sand Canyon Pueblo.*
>
> 'From eating only grass seed*' the people are given a variety of corn in many colours. Under the direction of the Twins, the people are transformed in appearance.* 'This is

[132] Parsons (1996 [1939]:326) writes of the Zuni *Thle'wekwe* (Wood) society emblem as "A stick of office with a pendant of twelve stone points belongs to the Oraibi War chief, and to the Zuni War chiefs belongs an arrow-tipped stick or staff which is held in alternate years by Elder Brother and Younger Brother, the transfer taking place at the War society-Wood society ceremony." The "two fetishes of the *Thle'wekwe* society are kept, respectively, in Crane clan and Corn clan houses; and the offices of society chief and speaker are, or were, filled by a Crane clansman and a Corn clansman...In 1919 at Zuni two Bear clansmen were initiated into the *Thle'wekwe* society because it is necessary for the sand-painting [done in ceremony] to be made by a Bear clansman. The chief of the Kachina society should belong to the Antelope Clan (160-161)." Bear, Crane, Corn and Deer are linked with Katsina at Zuni in the historic period. "The only other curing societies of Jemez [Pueblo] are Flint and Fire. Flint and Fire are the "Bear medicine" societies among Tewa" (133).

[133] "Bow-on-top village" is the English translation of the name of the Hopi Pueblo, Awa'tovi. The Bow clan was powerful there until 1700 when group conflict caused its destruction (Whiteley 1998:134-135). At Emergence the Bow Clan ceded leadership to the Bear Clan because of systemic corruption in the Third World (134-135).

the way you people ought to be; you ought to be like us,' *say the Warrior Brothers. Their journeys and trials continue.*

At a place called Tenatsalin they stop for four years.[134] *Tenatsalin is named for tenatsali, an unidentified plant known to act as a narcotic that 'belongs to the Rain chiefs and to the medicine societies' (220). Eventually they are stopped in their migration by Chakwen woman (a mythic giantess) and a battle ensues. The people and the Brothers are unable to pass by.*

'We can do nothing' *state the two Ahayuta*. 'Prepare meal and turquoise for us! We are going somewhere; we shall be back soon.' So the *[Zuni]* women gave them meal mixed with turquoise. After they had gone a little way from town, they made a ball of the meal (to throw ahead for their road).[135] They looked up at the sun in the middle of the sky... 'That's where we have to go,' they said. When they got to where the Sun was sitting, *the Brothers sought council. The Sun father gave the Elder Brother* 'his' *turquoise.*[136] *The Brothers return to confront the giantess.*

Elder Brother walked in front of all the people, and let go his turquoise. He missed, and his turquoise went to the north at Shiprock. A bear was there in hiding. He heard the turquoise coming, and he stood up and waited until it got there. It came swiftly, and it hit him in the belly. He bent down. It almost broke his backbone. Elder Brother followed his turquoise. Bear said, 'You hurt me very badly. I am bent double.' Ahayuta said, 'You are all right. This is the way you always will be. When your back was straight, you did not look good, but now, although you do not seem to be looking at anything, yet you are looking. Therefore everybody will be afraid of you. You look good.'

Younger Brother said, 'Now I will do it. I told you that you would miss.' He went in front of all the people and let go his turquoise killing or wounding the giantess.

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[134] Hieb (1972:178) notes of the archetypal number four in Zuni life as representing "basic categories" of "worldview" where space, time, colour, and number are constantly replicated. In the Emergence narrative here, the Zuni people travel and stop every four years. In Hieb's description of the Zuni Koko (Katsina) summer dance series, the Koko perform four sets of ritual dances in four plazas accompanied by four songs in each dance sequence (177-178). The numerical archetype confers a cosmological significance to the cessation of migration that, if indeed the case, also elevates the acquisition of new knowledge during the respite in travel so notable in mythic narrative, is sacralized as part of the movement towards becoming Zuni or, in the case of Hopi tradition, "Hopi." The same significance can be seen in Harvey III's (1972:199) description of the cosmological/philosophical system of the Pueblos as a "life-road" or "life-way." "Both Isleta and Hopi informants affirm that four years are required to learn the beginnings of ritual. While the number is symbolic, four years are required for the cycle of full initiation of Hopi," he writes (207).

[135] Roads are made of cornmeal and/or corn flour. In ritual corn meal trails or roads lead to altars (Fewkes 1902). The "turquoise" in this instance I take to be ground turquoise, possibly associated with sacred meal or a specialized grinding agent (which brings to mind the turquoise rock fragments from midden 1214). The turquoise in the following reference is said to represent a "rabbitstick" of the Sun Father.

[136] Parsons (1996 [1939]:225) records that the "turquoise was described as a rabbit stick," that the "Western Apache refer just the same way to the turquoise of the war gods, a swordlike weapon," and "Navaho war gods have clubs of precious stones."

Later, the two Ahayuta went to the top of their high rock. They put up stones to sit on, they fixed their pottery drum, they put meal on top, and they called from the fourth inner world Whirlwind, Wool-Rolled-Up, and other raw persons (supernaturals). So they came out to sit down in the daylight. When all the people got there, Elder Brother said, 'is there any Yellow Corn clan among the coyote?' At last they found him, a Yellow Corn clansman. They made him beat the drum. Elder Brother said, 'is there any Deer clansman?' At last they found one. 'All right. He will be my father [*ceremonial father*]. I will belong to this clan,'* Younger Brother said, 'is there any Bear clansman?' They found one. 'He will be my father. I will belong to this clan,' said Younger Brother. When everything was ready, the coyote Yellow Corn clansman beat the drum.

The next day the Twins and the two clansman of the Deer and Bear clan are referred to as the "four War chiefs." The people continue to migrate and stop for repeating periods of four years continuing to face obstacles and gain new knowledge (adapted from Parsons [1996 (1939)]:218-226).

* Parsons' footnote: "A very curious inconsistency, since you do not belong to the clan of your father, ceremonial or actual" (1996 [1939]:226).

The central theme is transformation through durable and reciprocal relationships. The mythic War Brothers, the Twins, the Elder and "Echo" (the Younger Brother)(Parsons 1996 [1939]:Table 2) continue to exert their influence in contemporary War Brother image repatriation efforts (Ferguson et al. 2006), an ultimate re-balancing act of reciprocity. Key features of the reciprocity principle in the Zuni narrative include:

- Using a rainbow bow and lightning arrow, the mythic Twins pierce the *sipapu* (the entry into womb of the Fourth World) and bring the people into the light of the Sun Father and aid in their transformation to human form. They offer continued assistance in migrations.
- The people acquire knowledge through transformation of their appearance to that of looking like the Warrior Brothers, in effect, *becoming* like the Warrior Brothers, able to mitigate their own concerns through the transfer or access to mythic power.
- The earthly representatives of the Warrior Brothers are vested in the Deer (Elder) and the Bear (Younger) clan leaders (as ceremonial "fathers").
- The mythic Elder Brother errs but the results are transformed for the good—the Bear's story of trauma becomes one of a better version of himself through transformation. Similarly, although not noted in these selections, the death of children is made tolerable by the efforts of their parents to return to the place of Emergence to reclaim them as living still (Parsons' [1996 (1939)]:216-222).
- The corruption of the Third World and the ceding of Bow Clan leadership to the Bear Clan as recorded in Whiteley (1998:134-135) demonstrates how transgression, improper

> action and inappropriate response are reconfigured. Leadership is not narrated as wrested away from the clan but conceptualized as "ceding" leadership. The word suggests that there is some acknowledgement of wrongs, or that by "ceding" there is room for acknowledgement or negotiation.

The message of the *standing bear* hinges on error followed by proper action and thus, good consequences. The act of "ceding leadership" suggests that the appropriate action is to back down and allow for reconfiguration. A similar situation occurs when the Bear clan leader errs in initially turning away the Badger clan at Oravyi in mythic times (Whiteley 1998:113-114). The error of the Elder Brother in wounding the bear lays out the process of how trauma is reconfigured for stabilization and recovery. The events have been reconfigured for "good."

The tradition of accepting newcomers into Hopi villages based on their ability to capture power and exert influence is mirrored in the narrative where the witch asks the newcomers if they "have something useful." This can also be gleaned in the Bow Clan ownership of Shalako (*Sa'lako/Shalako/Sháalako*) "a rare and powerful Kachina ceremony linked with *Wuwtsim* initiation" (Whiteley 1998:135). The *Shalako* Katsinas, owned by the Bow Clan, and *Powamuy* ceremony, owned by the Badger Clan (Parsons 1996 [1939]:138*, 201; Whiteley 1998:118, 135), are examples of the ownership of important and influential ritual. The following commentary hints at the power vested in some groups and in the concept of transgression:

> Only Bow among the Hopi clans regularly practiced human sacrifice in earlier times. All these ritual prerogatives entailed a rather awesome reputation: 'If you get in trouble with the Bow clan (which controls important ceremonies), you might do nothing. [137] You can't face them; you can't get even with them. They could kill you. I'd let it go...The Bow clan is powerful' (Brandt 1954:181-182 in Whiteley 1998:136).

The mythic events at Shiprock tell us about Puebloan cycles as much as they inform of the reciprocal transference of power and the challenges Pueblo people faced in their mythic migration journeys. To accomplish their supernatural deeds, the War Brothers draw strength from human intervention, choosing an earthly clan as allies that through roles and obligations are equated as equal in power. A rent in the transcendental reciprocal cycle is embodied in the theft of War god images from their Zuni shrines, actions that can only be corrected with appropriate initiation in rebalancing the cosmos (Ferguson et al. 1996). Time is meaningless in this response; actions propel the solution and the redress. People's capability to access power distinguishes their authority. Such themes did not just appear in Pueblo IV, they were present before.

[137] Whiteley (1998:136) notes that the Bow Clan is also unusually associated with madness and witchcraft, "as a direct result of the *wu'ya*, clan 'totem' or 'ancient.' The death of the last Bow Clan member in the 1960s is thought to have been the direct result of internal sorcery (136).

Symbolic content: ideograms and artifacts of the social contract

> The foam cap (on the great waters) became instilled with life, and bore twin children, brothers one to the other, older and younger, for one was born before the other. (from *Creation and the Origin of Corn,* Cushing 1920:24).

Architectural and artifactual evidence reinforces my contention that block 100 contains cosmological content. The rock art in this block is abundant in comparison with what is known about other architectural blocks at Sand Canyon Pueblo. An image of concentric circles with a central dot is pecked on the wall above the firepit in tower 101 in style similar to that painted on the Warrior Room murals at Walpi. Cole (2009) writes of such imagery as

> abstract-geometric motifs [such as the concentric circle design pecked above the firepit in tower 101] are assumed to be conventionalized depictions of life-forms and objects; ideographs; diagrams of the sky and landscapes, routes of travel, or social relationship (linked clan signs, for example); and narrative figures related to ritual and ceremonial events...elements symbolic of social and totemic relationships and illustrative of events and oral or narrative histories (2009:30-31).

The concentric circle in the tower looks like an ideogram of linked clans. The *Kokopelli* figure pecked onto the original floor surface of kiva 108, which conforms to later historic imagery of Zuni flute players and flute society motifs serves as a tangible link to Bear clan and a Flute society (Parsons 1996 [1939]:192).[138] The Elder War Brother blows a flute in mythic war events, his earthly representative, elder brother war chief does the same in history: in a clash between Hopi and Hano warriors with the Spanish in 1716, the War Chief blew a flute. Flute players lead the *Shalako* (the Zuni warrior katsina also owned by Hopi Bow Clan) away from villages (381). The “War Captain” of Zuni blows “the flute of *Ma’sewi*” during the two-day war dance formerly held in April or November (537). The Bear and Blue Flute Society are connected through Warrior Twin ideology and their directional associations with the setting sun. The architecture of the two side-by-side kivas of block 100 (the *Cleome* kiva 102 and the *Kokopelli* kiva 108) parallels the historic connection between bear and flute as socially linked groups. The connection between Flutes and Bear clan is further described as follows:

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[138] Parsons writes, “That ‘humpbacked flute player’ so intriguing to the archaeologist in the Southwest is Locust.” At Shipaulovi (on the Hopi Mesas) “the Locusts” in narrative “keep their kiva warm by playing their flutes, and in the same way they melt the snow for the Snakes [society] in winter prayer-stick-making, priests will throw pieces of a locust on the fire ‘because the smoke and odor bring warm weather’ [Voth 1905b:217). Parsons records the locust’s song: “Hao my fathers, hao my mothers! Drab Flutes, Blue Flutes [the societies]. My fathers, beautiful living in summer will begin for us. In summer blossoms wave, in summer blossoms will sway” (Parsons 1996[1939]:192). Their connections with cardinal directions and the Warrior Brothers suggests kiva 108 was at least at one time aligned through a flute society with the Bear Clan (effigy) in tower 101 and the west kiva of the D-shaped building at Sand Canyon Pueblo.

> At Zuni and Sia [pueblos] not the Maize or Earth Mother but the War Brothers established the curing societies. Zuni gets all its 'rules' from the Twins, an idea readily entertained, since the Twins are impersonated by the War or Bow chiefs, elder brother and younger brother, who make or enforce the 'rules' of the town...To their shrines are carried miniature bows and arrows, and clubs and netted shields, and their cedar-girt ground altar on Corn Mountain, miniature implements of their games, and, annually, new images, made from a lightning-riven tree, by specially entrusted members of their clans, Bear and Deer [The Warrior Brother images left on shrines to degrade]. On First Mesa there are three sets of War Brother images—stone images kept by a Tewa chief, by the Kachina society chief of Walpi, and by the War society chief—and the Brothers are impersonated at the War society ceremony as kachina (Parsons 1939:183).

A row of eight stone War god effigies on the altars of the Snake and Kapina societies at Sia Pueblo include a carved image of *Ma'sewi*, the Zuni Elder Brother (Parsons 1996 [1939]:Table 2) decorated with a necklace of bear claws[139] (1939:687-688). The image with a stone hatchet represents *Uyuuyewe,*[140] the Zuni Younger Brother. A bear, a bear cub, and a wolf effigy also decorated the altar (the bear and wolf are associated with west and east directions respectively).

Bow warriors, the Elder and Younger Warrior Twins, and the Bear share cosmological interdependence that is spatially aligned with the movement of the sun as it sets on the horizon and thus a connection is possible between the west directionally located block 100, and the D-shaped building. Hints of the bear-warrior interconnectivity is evident in Parsons' additional description of bear paw imagery painted on the masks of War Brother representatives, the bear paw is "painted on the *Ahu•te's* mask because *Ahu•te* is a warrior"(1996 [1939]:341) providing a direct association with bears and warriors, a theme that is architecturally built into the style of the D-shaped building.

Bears and clans are likely not new configurations first tapped into at Sand Canyon Pueblo but persistent from previous times and proofs of ideological continuity with Pueblo Bonito. The skeletal foot anomaly of the robust man in block 100 (HRO 2) has its ideogrammatic representation in rock art also. The six-toed footprints on the cliff behind Pueblo Bonito is found on human foot bones found in one of Bonito's west burial rooms (room 330). The six-toed man in block 100 resided, as he apparently did, on the western arm of Sand Canyon Pueblo, and is within a directional scheme that has its origins in religious symbolism associated with the Bear, the setting of the sun, the dusk, Blue Flutes, and the Younger Warrior Brother twin. The fact that six-toed prints are found, but not

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[139] Parsons (1996 [1939]:Table2) identifies bear imagery with the Elder Warrior Brother and the Bear Clan with Younger Warrior Brother.

[140] Younger of the war twins and is alternatively spelled as *Oyoweye*. Parsons (1996 [1939]) references the War Brothers' wooden images with various spellings. In volume II of her Pueblo ethnology she also refers to them as *Ahaiyuta* (627) and *Awele* (919) so inconsistencies of spelling are common. *Ma'sewi* is also written as *Maa'sewi*.

commonly, imprinted on rock makes the argument for this anomaly as connected with power through its metaphoric references of transformation and identity. The walking human prints and bear tracks mirror the transformation of shamans and the bear in oral tradition that taps into the significance of medicine (plant and animal) as part of underlying reciprocal principles founded on usefulness and mutual aid. The rock art of Newspaper Rock (Figures 6.4-6.6, chapter six) lends additional legitimacy to this assessment. In the case of six-toed prints, a genetic component is added to the reference of power. Furthermore, SCP's great kiva, its peripheral rooms, and the D-shaped building with its limited access and unusual features are testament to the influence of what an outward display of power and *ritual* power can look like when conveyed through architecture.

As described in chapter six, Whiteley (1998:111) writes of Hopi language forms as "condensed word images." I have attempted a simplistic version of the same by referencing various Sand Canyon Pueblo structures with labels that play on imagery in an effort to capture a sense of their archaeologically defining features. This aims to bring to mind Pueblo ideas as a referential strategy for keeping track of what is indeed a "densely laconic" (114) *site*. My other purpose is to interject a version of "lived" past into the interpretative process. Such labels also serve as a type analytical "short form." The twin kivas of the D-shaped building was a label of analysis I applied prior to any detailed ethnographic research and is a clear example that "there can be no private language," nor "private culture whose key saliences and engagements are... incommunicable to others" (14-15). The "twin" concept proved, much as did the "bear," to be a productive interpretative category representing a cultural keystone that realigns the D-shaped building as ethnoevidence of the cosmological significance of Pueblo "twins" specifically the War Brother Twins. Ferguson and colleagues (1996) reporting of Zuni *Ahayu:da* (the images of the War Brothers) repatriation efforts has proven to be fruitful for understanding the quality of persistent and "invisible" themes—what persists and what *should not* persist, a continuum of metaphysical existence of things and ideas. The bear effigy was meant to persist and be passed on. The Warrior Brothers were meant to be represented in less obvious ways because they are cosmological, their "visibility" captured only in particular contexts and in particular places.

<u>Beyond Block 100: the Gods of War and the D-shaped building</u>

The "container in the centre" concept aptly describes the positioning of Sand Canyon Pueblo as a unique centre within a greater community (Ortman and Bradley 2002). I also see Sand Canyon Pueblo as a container not so much in the centre but "in the middle." A characterization that references Sand Canyon Pueblo's temporal position in Pueblo history residing as it does in an archaeological *middle* and *liminal* zone between such grandiose and remarkable expressions as the massive Pueblo

Bonito,[141] the occupation of Oravyi and the later rise of the Katsina Cult (Adams 1991). Le Blanc (1999) and Ortman and Bradley (2002:73) argue for evidence of a "reinvention of a Chacoan tradition" that would bring together compelling ideas and justifications elevating Sand Canyon Pueblo as somehow more able to manage, hold on, or prosper. This was not accomplished only by defensive features—walls, towers and siting capabilities, but by virtue of a very particular content contained in Sand Canyon Pueblo's smaller-scale but still cosmologically monumental buildings.

Much as the 13th century Christian church continues to assert influence on Christian ideology, acts, narrative, symbolism, art, architecture and objects, so too does the ordering of the universe in Pueblo history through similar means. I have shown in previous chapters that colour and directional cues are important components of the Pueblo ideological system in the categorization of plants and experienced through ceremony. Whiteley's (1998) analysis of Hopi naming traditions informs us of the depth to which these categories encapsulate existential themes. The "yellowness," "coyotes" and "foxes," among other things, have an immediacy that is hard to deny, transforming basic categories of colour, coyotes and foxes into things with great complexity and experiential depth.

The 13th century was violent globally and the events in Ancestral Pueblo are not so different, or the tenor of violence more so than elsewhere (LeBlanc 1999). This same propensity has persisted into the 21st century in all too merciless and visceral ways. Like human beings everywhere people seek to reason assault through compensation by creating situations that allow them to do better, respond appropriately, and avoid future trauma. The presence of an apparently abandoned bear effigy indicates the existence of Bear "people" in block 100 and therefore, reflects a Warrior Brother, one inextricably connected to the D-shaped building. Using the themes of the Zuni *standing bear* narrative (described in detail on pp. 476-480), I examine the architectural configuration of the building to demonstrate.

<u>Ideological themes and architectural correlates</u>

As does the D-shaped bi-walled bow-shaped "Sun Temple" at Mesa Verde, the D-shaped building at Sand Canyon Pueblo, too, shares an outward appearance of the bow-shaped Pueblo Bonito. Bow imagery is not only apparent in these contexts but also in the bow-shaped walls and D-shapes notable for the ancient monumental villages of Pueblo Alto, Pueblo del Arroyo, Hungo Pavi and Chetro Ketl in Chaco Canyon. Two additional sites, Una Vida and Peñasco Blanco, have D-shaped walls enclosing large portions of their interior spaces. All can be described as monumental both in terms of size and message. Such architectural features serve as highly effective defensive strategies against

[141] The Pueblo Bonito temporal sequence is most associated with Early Pueblo II ca. A.D. 900s-1020 with "Classic Bonito" dated to A.D. 1020-1120 (Cordell 1997:191-192).

attack where scaling of curved walls leaves invaders exposed and vulnerable. But curved walls for defense would not be limited to a single wall, a circular village would serve defense far better if this were the case. It is clear that the D-shaped wall is meant to convey more. It does indeed image a "bow."

That D-shaped walls are not always used indicates that they hold symbolic meaning that goes beyond simply design elements or warrior themes (every village surely needs defense). To use such imagery would also claim alliance with, and properties of, the War gods' father, the Sun. Thus, the image of the D-shaped wall brings to mind a sense of the *all* powerful sun—the sun as it appears on the horizon moves across the sky. The sun's/Sun's passage is assisted by powerful and knowledgeable people who bring up the sun by putting on the colours of the sun's light as the Sun Father makes a first faint appearances in the sky (the grey and yellow foxskins of the Bow Priests). In this respect the bow indicates not simply defense but the ability to harness the most powerful aspect of the environment. Sand Canyon Pueblo's site-enclosing wall and D-shaped building can be expected to contain this powerful essence also. Parsons' description of Sun Father imagery suggests that sun and shield motifs can be viewed from a perspective of war and of migration symbolism.

> Like men, the Spirits are of migratory habit. Sun makes his diurnal journey, in Keresan tale, to carry his mask or shield across the skies, or, in Isletan tale to make his three daily stations, stopping at the midmost to descend to earth and 'meet his sons' (Parsons 1996 [1939]:200).

The sun, shield and shield-carrying warriors of Four Corners rock art (Cole 2009; Schaafsma 1965:16) document durability of this connection into ancestral time, the peoples' migration mirroring the sun's passage back to its place of emergence beyond the horizon. Archaeological evidence confirms similar warrior connections. Adams (1991:90) notes that a Warrior Society can be distinguished in 11th century Mimbres sites, a group distinct to the Mogollon Mountains of southeastern Arizona and south-central New Mexico. Warrior societies dominated in the Upper Rio Grande Valley in the 15th century. The same organization can be linked with the Katsina Cult in the 13th and 14th centuries (91). Evidence of war god themes can be seen in the following ethnographic sources, evidence, I argue, that is built ("purpose-built") into the architecture of the D-shaped building:

- Sun Father is described as a shield thrown up in the sky (Parsons 1996 [1939]:212), the "Sun's course across the sky is interrupted when he permits his sons to carry his shield [Tewa]" at the midday point of the sun's journey.

- Sun Father "*has two houses for his daily use*," the sunrise and sunset kivas (Parsons 1996 [1939]:212; emphasis added). "The directions are determined by sunrise and sunset" (365). Known as the *Chupawa* (sunrise) kiva, and the *Uptsanawa* (sunset) kiva.

- “War Brothers established the curing societies. Zuni gets all its ‘rules’ from the Twins, an idea readily entertained, since the Twins are impersonated by the War or Bow chiefs, elder brother and younger brother, who make or enforce the ‘rules’ of the town” (Parsons 1996 [1939]:183). “There are also on the mesa many interesting shrines to the Sun father, Moon Mother, and Gods of War” [Zuni](Stevenson 1915:35).

- War Brothers are documented consistently in historic ethnographies as *Ahayute*, *Ayu·te* (Parsons 1996 [1939]) and *A-hai-iú-ta* (Cushing 1920). The Younger War Brother is also referred to as *Ahayuta achi* identified as *Uyuyewe/Oyoyewi* [Zuni](Parsons 1996 [1939]:Table 2, 243). The Elder War Brother is referred to as *Ahayuta achi* and named *Matsailema* or *Masewa/Ma·sewi* [Zuni](Table 2). *Pü'ükonghoya* (“little smiter”) and *Pa'lüngahoya* (“echo”) are Hopi names for the Warrior twins (Parsons 1939: Table 2). The contemporary Hopi Younger War Brother is *Palöngawhoya*, the Elder is *Pöqangwhoya* (Whiteley 1998:90-91).

- The *Pöquangw* Brothers (the War Twins), who are just like their grandmother, Old Woman Spider (or Spider Grandmother), helps those in need. “She has ways of doing away with a person’s enemies” (Lomatuway'ma et al. 1993:461). The importance of the war twins can be seen in the Katsina kilts that have “*Pöquangw* tracks,” a design described as “both above and underneath are fairly narrow bands of black color decorated with paired markings of white” (439).

- War gods (*Ahayu:da*) whose removal from Zuni lands “resulted in such severe problems that Zuni religious leaders decided action was needed” (Ferguson et al. 1996:252). In 1980, the Denver Museum formally recognize *Ahayu:da* as an “animate deity crucial to the performance of [Zuni] religion”(255). Repatriation efforts of *Ahayu:da* was lead by Zuni Deer and Bear clan leaders and Bow Priests in consultation with their Tribal Council. The Council then enacted a Tribal Resolution recognizing the authority of religious leaders over sacred objects (Ferguson et al. 1996).

- The 1990 North American Graves Protection and Repatriation Act (NAGPRA) constitutionally accepts the cultural ownership of religious symbols. The War Brothers images are deemed essential to the practice of Zuni religion (Ferguson et al. 1996).

The sun’s positioning as it rises in the east will appear first from the roof of the D-shaped building’s east kiva, the midday point of the sun’s progress can be envisioned by the dividing wall that bisects the D-shaped building into halves. The timing and construction sequence of the D-shaped building captures a sense of Cushing’s (1920:24) poetic description of the birth of the mythic twins—“brothers, one older and younger, for one was born before the other.” The first kiva built is estimated to be the east kiva (1501). The tree-ring cutting record places construction around A.D. 1260-61. The bi-wall rooms—the circular passage of rooms that permit movement into the deeper and more secret space of kiva 1501—were constructed during the same period (Kuckelman et al. 2007). The west kiva (kiva 1502), however, has a tree-ring cutting date record that indicates it was constructed around A.D. 1270-71. A ten-year difference between the larger and more elaborate east kiva 1501 and that of the west kiva 1502 is indicative of a hiatus that I contend is a deliberate one. How better to build a “younger”/later twin than delay construction? Further support for my contention of a deliberate strategy to reflect “elder” and “younger” is the fact that the west “twin” kiva could have been built first, but was not. Here the directional cues are significant. Mythic and historic leaders are directionally associated, the cultural keystones in Warrior Brothers’ ideology are East and West. Elder Brother is aligned with the rising of the sun, the grey and yellow foxskins and the East direction. Younger Brother is aligned with the setting of the sun and the blue dusk of sunset. The time delay between kiva construction does not alter the architectural plan of the building. The delay does not suggest a decline in labour force or attention focused elsewhere, the building is not so imposing as to require such time. Rather, the sequence is highly suggestive of an architectural representation of the Elder and Younger Warrior twins as an architectural strategy to reflect “age.” Two kivas were clearly designed for this space, both within a space that looks like the sun as it sets and appears on the horizon. The replastering and resurfacing of floors and walls for upkeep indicates a relatively lengthy period of use for both kivas and demonstrates a commitment to the ideology behind the shape that I estimate begin ten years previous with the construction of the east kiva and a minimum of four years (if annual replastering was similar to historic pueblos) for a fourteen year use. The elaboration and positioning of the kivas also mirrors that of twins, particularly fraternal twins. The “elder” kiva is larger and slightly more northward (“higher”) in plan view, the “younger” is slightly smaller and more southward (“lower”) in plan view. The differences in size and elaboration are suggestive of elder, wiser council, the younger, less fully elaborated, an “echo” of the other, hence a reference to “echo” for the younger Warrior Twin (Parsons 1996 [1939]:Table 2; Waters 1977:4). Each function to capture the essence of the rising and setting sun: the early appearance of the sun to the east, and the later appearance of the sun in the west, one effectively born before the other.

Size is meaningful as a signifier. An example of the message of “size” can be seen in the case of the two War Brothers effigies at Walpi where “age” is represented through size. The larger of the two War Brothers’ effigies is that of the Elder Brother, the smaller, the Younger (Fewkes 1902:483-484). If we accept that the architecture of the D-shaped building at Sand Canyon Pueblo is aimed to send a similar message, then the size of the D-shaped building kivas is also meaningful. Additionally, aligned along a cliff edge, the building captures the rising and the setting sun, both cosmologically connected with historic Bow priests who function as a defensive society where one aspect is materially defensive, the other serves as an esoteric function, bringing the light up in the sky, a most potent display of power. The building with its north-northwest orientation, captures the rising sun but can be seen as an architecturally *built* sun, positioned on the horizon similar to the vision of the sun as it first appears on the horizon. The cliff face serves as the division between the earthly universe and beneath the rimrock horizon, references the cosmological world below. The space beyond captures the sky above the canyon, a world of the invisible as it overlooks the lower kivas and rooms of blocks 600 and 900 clinging to the lower benches of the cliff (Figure 6.1, p. 128, Figure 6.2, p. 131). The building is situated to capture a mirror image of the existential sky "kiva," home of the Sun Father in the space that occupies the canyon, its worldly counterpart sits immediately opposite aligned on a cliff face. Its presence on a cliff face with kivas and other buildings below provides the opportunity for Bow Priests or others to leave their kivas below the cliff, climb a ladder into the realm of the "sky kiva" and emerge secretly through the break in the rimrock beneath on the flat face of the biwall. Entry into the existential world of the D-shaped building could be experienced as through a rent in the underworld, the wall the midday point where the Sun Father hands over his shield to his Elder and Younger sons, a mirror image of the rainbow bow and arrow that pierces the underworld to allow the people access to the "now."

These ideas are further confirmed by "built" existential themes in the bi-wall. Ortman and Bradley (2002) note the bi-wall rooms are metaphorically congruent with migration symbolism. These constricted spaces with entryways allowing passage deeper and deeper into the world of the building, seems to convey a return to the place of Emergence where sit the two Warrior Brothers on either side of the *sipapu*, the place of Emergence (Parsons 1996 [1939]:184). The break in the rimrock situated immediately west of the dividing wall (bi-wall room 1509) permitted passage into the bi-wall rooms and the west kiva as conveniently placed closely aligned with the dividing wall between the kivas allowing secretive access from the kivas below into the bi-wall. This idea is consolidated when considering the overall architectural design of the interior space of the D-shaped building. Plot the course of the sun as it rises in the sky to reach midpoint and descent to the horizon at dusk and we have the shape of the D-shaped building, with the midpoint in the sun's course mirrored in the wall that bisects the two kivas. The message of this "built" ideology is one of the earthly home of the Sun Father within which lies the two fraternal twins, not identical but separate and separated, together in the same womb. A logical and congruent interpretation would be a building constructed to take advantage of the break in the rimrock to allow passage between the physical world of the village and the earlier world below. I suspect that the archetypal number four in Hopi cosmology may be reflected in the number of rooms in the west and east bi-wall although limited excavation does not allow for confirmation. (A series of four rooms is only obvious in the horizontal bi-wall rooms of the Sun Temple at Mesa Verde with its twin kivas and illusion of division built into its bi-wall configuration).

How the D-shaped building is publicly accessed adds additional support to my interpretation of the message behind the architecture. The tall height doorway on the west side of the bi-wall (and west kiva) opens onto the west plaza (plaza 1500). The doorway permits direct access into the west kiva and side access into the bi-wall rooms. Limited excavation of the building did not reveal a similar doorway on the east side of the building; one could be present although it is unlikely. From the perspective of the cultural significance of rising and setting sun symbolism, it would not be logical for an obvious doorway in the east half of the bi-wall. If such an entry exists it would be clearly visible to anyone on the east half of the village. If the east kiva was constructed as a more deeply sacred space, and certainly its elaboration suggests this, it would be reasonable to assume that entry into it would require a more convoluted and secretive passage. Whiteley's (1998:113) description of the Sun putting on the grey and then yellow ladder-pole foxskins from the kiva roof top as acted by Sun/Bow priests reflects a transformation of knowledgeable and potent people taking on the Sun's role in creating the dawn from the east kiva roof. Much as the Bear shaman is transformed into an actual bear, a similar transformation of Bow Priests occurs as they bring forth the rising sun. The act of transformation from grey light to yellow light on the east kiva rooftop would preclude these individuals from entering the east kiva through any type of obvious access point. The mysticism and power would be diminished.

Casa Rinconada, the great kiva of Chaco Canyon, offers intriguing evidence of a building that also embodies the same ideas as I have suggested here: a kiva divided into two mirrored parts, each half having similar features (huge parallel floor vaults) and oriented similarly at north-northwest. Both the D-shaped building at SCP and Casa Rinconada are divided, SCP by a wall and a secretive entry and passageway, Rinconada by a wide secret passage, each suggesting two distinct "east" and "west" configurations. Borrowing on themes of cardinal directions and divisions, SCP co-opts both Rinconada's great kiva vision and Pueblo Bonito's elaboration of the same.

<u>Attributes of influence: the directionally dependent two-kiva system of historic Pueblos</u>

The ideas I have suggested for Sand Canyon Pueblo are not coincidences. Parsons (1996 [1939]:10) describes historic Pueblo social organization as a "two-kiva system" based on the social organization of kiva groups. Although clans serve to set people apart in particular ways, kiva group membership crosscuts these boundaries. Each individual belongs to the kiva group of his or her father and mother. This changes only for women when they marry, after which the woman then belongs to the kiva group of her husband. The two-kiva system is part of an elaborate organizational scheme that aims to bring social balance and cooperation. This organization creates and crosscuts boundaries. Ortiz (1972) reaffirms the significance of boundaries in Pueblo life that have implications for the interpretation of ancestral Puebloan sites. He writes,

> The first generalization that can be made about the Pueblos is that they all set careful limits to the boundaries of their world and order everything within it. These boundaries are not the same but, more important, the principles of setting boundaries

> are since all use phenomena in the four cardinal directions, either mountains or bodies of water, usually both, to set them. In pre-Newtonian fashion, all believe that the universe consists of three cosmic levels with some applying the principle of classification by fours to postulate multiple underworld levels, either four or a multiple of four. All peoples try to bring their definitions of group space somehow into line with their cosmologies, but the Pueblos are unusually precise about it.
>
> This precision has many, almost inexhaustible, implications because the Pueblos attempt to reproduce this mode of classifying space on a progressively smaller scale. Since all space is sacred and sacred space is inexhaustible, these models of the cosmos can be reproduced endlessly around them (Ortiz 1972:142).

The east and west alignments of the D-shaped building kivas conform to classifications of sacred space in Pueblo worldview. Some of the "inexhaustible" connections with such characteristics confirm a deliberate division of people and of worlds based on cosmic significance, the observation and tracking of the sun across the sky. The most obvious of which, as I have noted, is the midpoint in the movement of the sun and the brief "stopping point" at midday. The wall or division as related to the progression of the sun as it moves across the sky, divides the world into east and west. The cosmological ordering of Pueblo society along these lines is perpetuated in repeated seasonal ceremony. These enactments are not limited to clans but scales down into finer connections between groups, group responsibilities and ownerships. All are founded on concepts of proper behaviour, redress and rebalance. Ortiz describes the underlying reciprocity principle in Pueblo worldview in the following passage:

> A world view [as distinct from religion] provides a people with a structure of reality; it defines, classifies, and orders the "really real" in the universe, in their world, and in their society. In Clifford Geertz's phrase (1957), a world view 'embodies man's most general conceptions of order.' If this is accepted as a working definition, then religion provides a people with their fundamental orientation towards that reality. If world view provides an *intellectually* satisfying picture of reality, religion provides both an intellectually and *emotionally* satisfying picture or, and orientation toward, that reality. Since religion, as here defined, carries the added burden of rendering endurable such unpleasant facts of the human condition as evil, suffering, meaninglessness, and death, it must be more instrumental than expressive, more thoroughly constitutive of the social order than merely reflective of it (1972:136, emphasis in original).

Trauma and banished memory are part and parcel of worldview whether we are aware of it or not, imposing effects on how people respond to horror in its many forms (Herman 1997; Ortiz 1972). The underlying theme of Pueblo "gifting" and reciprocity is a rebalancing and managing of the vagaries of life. The same phenomena is typical of trauma in the broadest terms where the victims or observers, in effect, "gift" in some manner the lessons they learn to those who have been so far, more fortunate than they. Appleton (2014) asserts the phenomenological basis of therapeutics in the face of trauma is art, “turning fear into image.” “Turning fear” is the root of our *imaginings* of a better world and is well-supported at Sand Canyon Pueblo and later religious visibility in Pueblo IV. “The same generativity can be seen in themes of welcoming for the betterment of all as described for the “beautifully ascended” *Patsavu* ceremony (Whiteley 1998:114). The diverse building styles at Sand Canyon Pueblo, underground kivas, Pueblo II styles integrated with Pueblo III forms suggest that many came together from different traditions. The core values of welcoming and reciprocity made it possible to create a village of *cosmopolitan* style. Some ethnographic examples of these themes include:

- In the Zuni Emergence narrative (*the standing bear*) the Younger Warrior Brother gifts the people passage in their migrations in the Zuni narrative making up for the traumatic error of his Elder Brother in the wounding of the bear at Shiprock.

- The referencing of various people as younger and older brother in Parsons’ (1996 [1939]) *Pueblo Indian Religion* confirms the notion of partners in problem solving and sharing of ceremonial and social obligations. Leaders are given the labels of Elder Brother and Younger Brother and seen as the earthly representatives of their mythic counterparts. Although some groups conceptualize their spaces in terms of the number three (Ortiz 1972:142), there is a clear division, a dividing line between particular numbers of groups. “Of the six Zuni kivas, three are elder brothers to the other younger brother kivas; each pair co-operates in dances,” the summer and winter people of Taos Pueblo is an example of a social division that assigns important ritual and seasonal roles, managing through their efforts, the gifts of the seasons (Parsons 1996 [1939]:143).

- Much like the acceptance of new groups into existing Hopi mythic villages, the question “*Have you something useful?*” is asked of the mythic Warrior Brothers by two witches sitting at the entry of the underworld (Parsons 1996 [1939]:220; emphasis added), demonstrating the themes of reciprocity and conditions of balance and redress. (The “ceding” of power for the various clans allows room for mistakes to be problematic but not unresolvable.)

- “At early dawn [the people on Emergence] put down their sacred possessions (water and seed bundles) in a row. After they saw the sun, they could not tell which was which of their sacred possessions.” The people are then given particular things. In the Zuni version, Spider Grandmother, grandmother of the twins, gifts the sacred possessions (Parsons 1996 [1939]:219) for the benefit of all bestowing mythological import to those who now own them. Ownership, then, is reconfigured as ideologically vested in the power of existential beings.

Reciprocity and gifting function to distribute knowledge and abilities through owned and ritually enacted ceremony by particular groups for the benefit of all. Although differences can be seen in the organization of various clans and societies in historic documents, themes of reciprocity, and proper behaviour are clear. The mythic Warrior Brothers act this out and identify several clans as prominent. The brothers ally themselves to Deer (Elder Brother) and Bear (Younger Brother) clans but other groups are influential (Corn and Coyote clans). The idea that the War Brothers are confined to a cultural concept of violence is out of place with the reality of reciprocity and balance that underpins the entire scheme. The elaborations reflect the reality of Pueblo life burdened as it was with almost continuous cycles of traumatic disruption, be it drought, war, illness, and the death.

War certainly did not cease after the Mesa Verde depopulation. Conflicts with Utes, Apaches, and Navajo from the seventeenth to early nineteenth centuries were "almost continuous" (Fewkes 1902:482). The Warrior room, described as "room of the War-God" at Walpi was used only for annual closed society meetings of the Eagle Clan leader (a War chief). The room was second storey rectangular room above the house of the Eagle Clan (Eagle is an east direction association [Cushing 1896 in Green 1979:186]). "Certain secret rites performed before idols of the War-gods and that of their "mother," or "grandmother," "the Spider-woman" were performed there (485). The room is accessed from the roof by a ladder and has a single "fireplace" in one corner. The ceiling is low (the D-shaped tower room 1008 with its multiple sealed over firepits comes to mind). The room contained "warrior fetishes and paraphernalia" (Fewkes 1902:484-485). The society corresponds "in a general way to the Priesthood of the Bow at Zuñi but in the Hopi pueblos this society has less power than the Zuñi priesthood. Its annual festival is called *Momtcita*, the prominent idols being the Spider-woman and her twin offspring, the Little War-gods" named *Püükoñghoya* (the largest effigy and Elder Brother) and *Paluñahoya* (the smaller effigy and Younger Brother or "echo")(483-484; Parsons 1939:Table 2).

Momtsit, (aka *Momtcita*) was the Warrior's society at historic Orayvi. Owned by the Bow Clan, *Momtsit* has its foundations in earthly representations of War Brothers themes (Whiteley 1998:91-92). At Orayvi, the cultural significance of the Warrior's society and War Chief can be seen in the following passage:

> The Qaletaqmongwi [Warrior Chief] was head of the Momtsit, or "Warriors," ritual sodality. It is clear from documents of the 1880s and 1890s...[that] the Momtsit was owned jointly by the Kookop [Fire] and Spider clans...The Qaletaqmongwi was the earthly representative of Pöquangwhoya, the elder of the "War Twins," and was often assisted by a representative of Palöngawhoya, the younger brother.
>
> *Qaletaqmongwi* is the War Chieftaincy and deemed the earthly representation of *Palöngawhoya*, the Elder Brother (Whiteley 1998:91-92). The role of the War Chief was to protect the village from outside invasion. In the 1890s, the War Chief position was held by *Qöyangayniwa*, leader of the Badger Clan. "In times of peace and harmony, the *Kikmongwi's* [village chief] role is considerably more significant; in times of external stress and/or internal crisis, the *Qaletaqmongwi* assumes a prominent role (Whiteley 1998: 91-92).

The cooperative redress and rebalancing acts of leadership are laid out in these two cooperative but distinctive roles, one ceding leadership to the other under particular social conditions. Each has unique qualifications within the context of war and peace. The two predominant leadership roles are founded on clan connections associated with the rising and setting of the sun and its directional partners, east and west. In the late 1800s, the Badger Clan had ownership of the War Chief position, at the same time the warriors' ritual society was owned by the *Kookop* and Spider clans. To add layers, the Spider Clan is linked with the Bear clan through its association with the west/sunset kivas. *Kookop*, Coyote and Desert Fox, Cedar (juniper), Millet clans,[142] and *Maasaw*, an ancestral emblem of the *Kookop* clan and a Hopi deity associated with fire and death (Whiteley 1988:79), made up another grouping or phratry.[143] It is evident from the early literature (Cushing 1920; Parsons 1996 [1939]; Whiting 1939) that clans are grouped according to their connection with directional cues and Sun ideology.

The importance of colour as a symbolic element reinforces the experiential nature of Pueblo thought, organization, and religion. Cushing (1896 in Green 1979) documents Deer, Antelope and Turkey clans are aligned to with the east direction (Elder Brother/White); Bear, Coyote and Tansy Mustard ("Red-top plant/Spring-herb") clans are aligned with the west direction (Younger Brother/Blue). The Badger Clan at Orayvi is a South clan, but its importance is signified also by its connection with Maize and Tobacco clans at least in the late 1800s at Zuni Pueblo.

A more comprehensive study of the organization of social structure is beyond the scope of this analysis but the Coyote Clan, a key player in the case of the Zuni Emergence narrative, is clearly singled out for special attention in Pueblo Emergence symbolism. A predominant Hopi clan, *Kookop* (Fire) has been both named the "Coyote" Clan or categorized as a clan associated through the phratry system with the Coyote Clan (Whiteley 1998; Whiting 1939) (Table 12.2, over).

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[142] The Indian Millet clan is identified as *Oryzopsis hymenoides* (Indian ricegrass) and grouped with the "Horn" society as recorded by Whiting (1939:47).

[143] In previous chapters I have referred to phratries as "groupings." Phratries are defined by the following criteria: an assumed or believed relationship between clans, with ceremonial and political importance that may employ symbols to signify membership (Schwimmer 1995). Hopi phratries "are associated mythologically with the origins of their totems. The usual example cited is Phratry I (which at First Mesa and Second Mesa includes others besides Bear and Spider). During their migrations, a group of people came upon a dead bear and decided to take this animal for their *wu'uya* [totem]...the last group found a Spider spinning her web between the bones and took *Kookyangsowuuti* (Spider Grandmother) for its *wu'uya*"(Whiteley 1988:53-54). To add to the complexity, religious societies undercut these combinations being of three ranked orders (Whiteley 1988:59; 1998:57). Hopi delineate kinship, clan, phratry, society and kiva. "Each of these organizations has various devices for increasing or maintaining its own social solidarity. Each system of organization also overlaps the others in terms of membership, so that an integration of the whole is achieved (from Eggan 1950:116, Whiteley 1988:59).

Table 12.2 Zuni clans at the end of the nineteenth century (source: Cushing 1896 in Green 1979:186). I have highlighted items of significance when considering the D-shaped building.

Direction	**Colour**	**Clan (Zuni)**	**Clan name (Zuni)**	**Notes**
North	yellow	*Ka'lokta-kwe*	Crane or Pelican[144]	
		Póyi-kwe	Grouse or Sagecock	nearly extinct
		Ta'hluptsi-kwe	Yellow-wood or Evergreen-Oak	
West	"blue world"	*Ain'shi-kwe*	Bear	
		Súski-kwe	Coyote	
		Aiyaho-kwe	Red-top plant/Spring-herb	
South	red	*Ana-kwe*	Tobacco	
		Tâ'a-kwe	Maize	
		Tónashi-kwe	Badger	
East	white	*Shóhoita-kwe*	Deer	
		Máawi-kwe	Antelope	extinct
		Tóna-kwe	Turkey	
Upper/Zenith	"many-coloured"	*Ya'tok'ya-kwe*	Sun	
		Apoya-kwe	Sky	extinct
		K'yä'k-yäli-kwe	Eagle	
Lower/Nadir	black	*Ták'ya-kwe*	Toad/Frog	
		K'yána-kwe	Water	extinct
		Chitola-kwe	Rattlesnake	nearly extinct
"Midmost"	All of the above	*Píchi-kwe*	Parrot-Macaw	

Cushing (1896) reports that the Bear and Coyote are connected, aligned with the west direction, the colour blue and thus, the Younger Brother is also inferred for Coyote. At the turn of the 20th century, Orayvi clans showed similar groupings. Bear and Spider clans make up one phratry, *Kookop*, Coyote and Desert Fox make up part of another. Sun and Eagle are similarly grouped. Crane is linked with Sparrowhawk and Squash, Bow is grouped with Greasewood and Reed (Whiteley 1998:58).

- Whiting (1939) associates the "Fire-Coyote Phratry" as having four clans named after plants [Hopi]: Note that juniper and pine are important fuel wood sources.
  - Mescal or *Kwa:'ni* clan named for Agave.
  - Juniper or *Ho'ko* clan named for *Juniperus utahensis*
  - A second Juniper clan named ***Kokof*** also for *Juniperus utahensis*
  - Pinyon of *Tuve"e* clan named for *Pinus edulis*
  - The Eagle-Sun phratry has two clans named for plants: *Pa:'kavi* for the Reed (*Phragmites* communis) clan and *Te've* for the Greasewood (*Sacrobatus*

[144] Cushing (1920:29) notes that the Sandhill Crane clan is a medicine partner with the Bear Clan. Stevenson (1915:85) recorded the Sandhill Crane clan as owing "Sandhill crane all beans" medicine. See also footnote 57, page 190.

vermiculatus) clan (47). Emergence traditions indicate that the people climbed up through the *sipapu* on a reed.

- The *Kookop* and Coyote clans are tasked with defense of the village (Whiteley 1998:64). Parsons identifies *Kookop* as *Kokop* (note Whiting's reference to *Kokof* on the previous page) referencing this clan as a Coyote clan (1939:1243).

- Coyote is a hunt patron at Zuni (Cushing 1920:401*fn*).

The significance of Coyote (the yellow fox?) and the D-shaped building is related to unusual faunal remains identified as domesticated dog, wolves/coyotes, and foxes.

<u>Partnerships</u>

Canidae: dogs, wolves, coyotes and foxes at Sand Canyon Pueblo

The D-shaped building is notable for its deliberate and careful dog burial. Located under a stone slab outside the entryway into the west kiva, the burial indicates that dog, and particularly this dog was important in the context of the D-shaped building.

The durable connection between dogs/coyotes as defense has parallels at Sand Canyon Pueblo. Coyote Clan connections with War Brothers' themes may have connections with wolf (and sun) imagery on the east wall of the Warriors' Room (Fewkes 1902: PLXXII; Parsons 1939).

- Hopi naming traditions play on colour as an identifier used to describe both sun and coyote to intriguing effect. Sikyatki is a ruin northwest of Walpi, which was first settled by the Coyote clan. The members of the clan eventually moved away, and now reside in many Hopi villages (Lomatuway′ma et al. 1993:475). Whiteley identifies the morpheme *sikyangpu* as meaning "yellow," "yellowness," and *sikyaatayo* "yellow fox" (1998:112).

- The yellow dawn and the yellow fox connect the acts of putting up the sun up in the sky by Bow Priests with the fox and with the Coyote Clan. The identification of fox remains in east kiva 1501 is intriguing although findings of fox-sized carnivores in block 100 and the subterranean kiva 501 are also recorded, both west oriented architectural blocks.

- *Canis* sp. remains (dog, wolf or coyote) are identified in various blocks as single bones or bone awls. The abundance of these types of remains in the D-shaped building and the plaza on the west side of the D-shaped building indicate something different here. These remains do not look like a "food signature" based on the parts recovered. The connection with Wolf as a historic prey guardian of the East might leave something of this signature.

- The careful and deliberate burial of the dog at the entryway to the building (west kiva 1502) and full jawbones of Canid remains in the absence of other bones in the Plaza and D-shaped building kivas suggest, at minimum, something associated with dogs, wolves, coyotes and foxes plays a role not as a subsistence option but as protectors.

- "The wolflike dogs of Zuni" were used in hunting and are used as sentries against strangers and witches. "If need be" they serve as food for captured eagles [Hopi](Parsons 1996 [1939]:28-29).

- Dog-head Katsina and altar feature in *Ni'man* (Katsina Going Home) ceremony (Parsons 1996 [1939]:768).

- Snake and Kapina Societies at Sia Pueblo include images of Wolf and Bear on the ceremonial altar, accompanied, although not predominantly, by an image of Mountain Lion on the right and left of the altar. Amongst other objects placed there is "a line of eight stone images representing the War gods, Ma·sewi and Uyuuyewe and their warrior deputies of the mountains." (Parsons 1996 [1939]:688).

- Prayer feathers are attached to domesticated animals (including dogs) during the summer solstice at Orayvi made by the Walpi Sun chieftaincy (Parsons 1996 [1939]:555-556). The image of the sun on the east wall of the Warriors' Room at Walpi is decorated with a set of two feathers for each cardinal direction.

- Katsinas identified in murals at Hopi Awatovi and Kawaika-a villages include *Pooko* (Dog) and *Kookopölö*, "one of the Hopi Twin War Gods," are both pre-historic, or at least prior to 1630 when the Spanish mission was built at Awatovi (Adams 1991:72)

Canid bone awls were identified in various contexts from early occupation accumulations to later at Sand Canyon Pueblo, but those of deer and other animals also attest to the reuse of bone as normal practice. A connection between the creation of bone awls made of canid is not clearly demonstrated as consumption. The presence of faunal remains from large animals such as deer, lynx and mountain sheep in latest occupation deposits at SCP does not support an interpretation of dogs, wolves, coyotes or foxes as needed food or starvation rations. Parsons records the Hopi eating dog or coyote only in times of extreme scarcity. Other evidence suggests that dogs were considered pets or protectors over a long period of Ancestral Pueblo history (1996 [1939]:23; Guernsey and Kidder 1921:16-17). At White Dog Cave, northeastern Arizona, dogs were buried in the graves of two adult Basketmaker-era individuals. The mummified remains of a woman was accompanied by a small spotted terrier-like dog, a planting stick and many baskets (Guernsey and Kidder 1921:Plate 15). The mummified remains of an adult male, approximately 35 years of age, was accompanied by the a long-haired white dog similar to a sheltie. This individual also was interred with many baskets. The skeletal remains of approximately twelve domesticated dogs have been identified in the record of Chaco Canyon as a very particular type of medium-sized dog "with slender muzzle and high, elevated forehead" (Allen 1954:285). Allen reports that,

> two nearly complete skeletons [of *Canis familiaris*/domesticated dog] were found in addition to four other skulls in fair condition as well as a number of associated limb bones, which were clearly of domestic dog. One nearly perfect skull is that of a puppy...The skulls are all of one type, representing the common medium-size breed of dog, probably here similar to what I have called the Plains Indian Dog, or the long-haired variety such as Dr. Kidder and Mr. Guernsey found mummified at White Dog Cave, Arizona ... One is the skeleton of an immature dog [provenience unclear, from

> Canid remains collected from Pueblo Bonito and Pueblo Del Arroyo, Chaco Canyon](385).

Plate 101 in this source shows a dog burial in Kiva F at Pueblo del Arroyo, laid out in similar fashion to the dog burial outside the D-shaped building. At least 115 dog burials have been found in the greater Southwest in 90 separate contexts (Chenault and Lindly 2006:127). It is clear that the people of the ancient Southwest buried their dogs, sometimes with loved ones. The almost complete *Canis* sp. skeletons in northwest bi-wall room 1513 and southeast bi-wall room 1510, in addition to jaw elements in the twin kivas, are similar to Allen's descriptions of Pueblo Bonito and Pueblo Del Arroyo canid assemblages. The apparent burial of a puppy near the body of a baby in the great kiva peripheral room 813 at Sand Canyon Pueblo is a poignant reminder of the trauma that was end days and the importance of dogs. It is clear that ancestral Puebloans had an abiding relationship with dogs, wolves and coyotes. The identification of fox in the east kiva fits well with the imagery and associations of Bow Priests marking the rising sun by dawning foxskins on the sunset and sunrise kiva roofs.

Individual fragmented and unmodified faunal elements, such as foot bones and vertebrae of dog-like carnivores, were present in kivas block 100, 200 and 1000 in abandonment contexts but do not account for the unusual abundance and specific skeletal elements in the D-shaped building and towers. Deliberate burial, full skeletons, and jawbones are not the typical patterns of starvation debris. The protective and warning capabilities of dogs are consistent with a sound defensive strategy and congruent with ethnographic reports of dogs as protectors.Tables 12.3 and 12.4 (over) show the distribution of canid remains across the site.

Table 12.3 D-shaped building dogs: wolves, coyotes, foxes by number of individual elements by cardinal orientation. Only bones of significance are labeled. Many are fragments. Number of identified specimens are indicated in brackets.

Material correlates	**Plaza 1500 and midden layers**	**West kiva 1502**	**West bi-wall room 1513**	**East kiva 1501**	**East bi-wall room 1504**	**East kiva midden 1506**	**East bi-wall room 1510**	**Arbitrary unit 1520[a]**
	Dog burial plaza	*"Bear" kiva? Coyote associations and West direction[2]*	*Green pigment room*	*"Deer"/sunrise kiva?*	*Tall room with small pit*	*East wall trash*	*Red and green pigment room*	*Overlays kiva 1501 and 1521*
Canis familiaris (domesticated dogs)	Dog burial (1)	-	almost complete canid skeleton (1)[1]	-	-	-	almost complete canid skeleton (1)[1]	-
Canidae (dogs, wolves)	mandible (1) maxilla (1) rib (1) foot joints (2)	complete mandible (1)	-	-	-	(1)	-	-
Canis sp. (dogs, wolves, coyotes)	small fragmented elements (48)	ventilation system: maxilla fragment (1)	-	surface: bone with cutmarks (1) bench fill: bone with carnivore damage (1)	(1)	(1)	-	-
Carnivores fox-sized or larger	-	-	-	-	-	-	-	(1)
Fox (*Vulpes* or *Urocyon*)	-	-	-	bench fill: partial femur with carnivore damage (1)	-	-	-	-

Notes:
[a] Arbitrary Unit 1520 is material that overlays east kiva 1501 and its northwest oriented kiva corner room 1521.
[1] Muir (1999:94)
[2] Cushing (1896 in Green 1979:186).

Table 12.4 Sand Canyon Pueblo *Canis* sp. Assemblage (not including D-shaped building deposition): dogs, wolves, coyotes and foxes by number of individual elements organized by deposition and cardinal orientation.

Identification	**Block 100 (west)**	**Block 200 (west)**	**Block 500 (west)**	**Block (great kiva) 800 (west)**	**Block 1000 (east)**	**Arbitrary unit 1014[a] and 1015[b] (east)**	**East kiva block 1200**	**Arbitrary Unit 1216[c]**
Identifiers	*gateway block with bear, box and tchamahia*	*tchamahia mortar*	*tchamahia mortar*	*"lightning medicine"[d]*	*gateway block*	*overlays block 1000*	*tchamahia and midden 1214*	*overlays block 1200*
Canis familiaris (domesticated dogs)	-	-	-	-	-	-	-	-
Canidae (dogs, wolves)	kiva 102: (1) midden 103: (1)	-	-	midden 803: (1) modified	kiva 1004 bench: (1)	-	midden 1214: (1)	-
Canis sp. (dogs, wolves, coyotes)	arb.unit 1 (1) kiva 102: (1) midden 103: (6)	kiva 208: bone with cutmarks (1) awl (1) artifact (1)	courtyard 513: awl (2)	midden 803: (1)	kiva 1004 benches: (2) Tower 1008, surf. 1: scapula (1)	(1014)(1) (1015)(1)	room 1205: awl (1) midden 1214: scapula (1)	(2) awl (1)
Carnivores: Fox-sized or larger	kiva 107 hearth: (1)	-	kiva 501: modified bone (1)	-	-	-	-	-
"Young canine"	-	-	-	peripheral room 813 in the vicinity of baby burial (HRO 25)				

Notes:

[a] Arbitrary unit 1014 is the uppermost fill including modern ground surface, wall fall and midden over courtyard 10000, room 1005 and possibly all of rooms 1006 and 1007.

[b] Arbitrary unit 1015 is the uppermost fill overlaying kiva 1004 and two corner rooms 1017 and 1018 and the courtyard (1016) that encircles the kiva.

[c] Arbitrary Unit 1216 consists of uppermost fill of kiva 1204, rooms 1211, 1212 and 1215 and midden 1214.

[d] *Lightning medicine* is the Hopi name recorded by Stevenson (1915) for *Cycloloma atriplicifolium* (winged pigweed).

Sun partnerships: flute societies

> Mythological history and its reenactment in ritual or its reiteration in tradition constitute crucial features of clan identity in Hopi thought. Clan traditions are matters of continuous intraclan discourse that repeatedly reaffirms marks of distinction. Such marks occupy manifold frames of reference: mythico-historical, theological, ritual, geographical, archaeological, botanical, zoological, meteorological, and so forth. In short, *clans in Hopi thought are cosmological, not simply sociological, entities.* (Whiteley 1988:53; emphasis added)

Whiteley's description in the above quote spells out the pathway to understanding Ancestral Puebloan archaeological evidence as remnants of an underlying cosmological entity, "Sun," and persistent sociological identities. I have shown that "bear" as a leadership role is a conduit of mythic and existential potency. The finer scales of social organization so typical of the Pueblos (Ortiz 1972) have their distinctive material correlates in block 100. Guideposts to connections with cosmological meaning include the location of the block, situated as it is on the western arm of the village.in a position that conforms to the curve of a bow, whether signifying rainbow or weapon. In the curvature of the site-enclosing wall, the block is situated on the landscape slightly past the midpoint of the sun's progress as it moves towards dusk, the blue dusk of the west direction. The *Kokopelli*, flute player figure on the floor of the Pueblo II style kiva (kiva 108), solidifies the connection between residents of the block as partners. Historically, the Bear and Spider clans are linked through the phratry system, but a deeper connection is also evident—two societies are identified as having "ritual concern with the sun's movement" in Hopi organization (Whiteley 1998:113). These are the Drab and Blue Flute societies described by Whiteley that tie Bow Priest sun watching from kiva roofs with Flutes. The Drab and Blue Flutes ritual standards are the grey and yellow foxskins on the ladder poles of the sunrise and sunset kivas in historic pueblos. These are the foxskins dawned by Bow Priests to activate the light in the sky at sunrise. The Blue Flutes are the purview of the Bear and Spider clans. Whiteley (1998:113-114) describes the Drab flute or *Masilelent* society as having originated on the Hopi mesas from the mythic eastern kiva where the sun rises; the Blue Flute or *Sakwalelent* society originated in the mythic western kiva. The foxskins, grey (Blue Flute) and yellow (Drab Flute) are tied to the ladder-poles of each society kiva today (113). Following these ideas to their logical conclusion I imagine that the grey foxskin represents the point at which the yellow light moves beyond the midpoint of the sun's progress, transitioning into the realm of the Bear/West/Blue dusk world of the sunset kiva. At finer scales of Pueblo organization (Ortiz 1972), some historical data are additionally helpful in assessing these connections further.

A predominant theme is the connection between Bear and Spider clans, linked by phratry with Blue Flutes. The *Sakwalenvi* (the Blue Flute *Place*) was controlled by the Spider clan at Orayvi and the Spider clan leader "traditionally provided the *Kikmongwi*," the village leader chosen from members of the Bear Clan (Whiteley 1988:88; 1998:113-114). The *Kokopelli* image on the floor of block 100's older kiva twin is one of identity of a Flute society an additional connection between clan and phratry is evident in Pueblo III. The predominant interpretation of *Kokopelli* is one of a "flute player" with a seed-filled hump on its back. These interpretations are not inconsistent with sun-watching for planting but other information indicates a deeper more cosmological association between flutes, flute societies, War Brothers, war and clan partners.

- "The mythical prototypes of the Flute societies continue to perform in the sunrise and sunset kivas, but instead of putting up foxskins on the kiva ladder-poles they magically raise up the live animals... clearly a nexus of mythological ideas associating yellow foxskins and yellow dawn light" (Whiteley 1998:113). "Moreover, Hopi myth and ritual are mutually integral (as above with the Flute society). Name images evoking ritual activities simultaneously invoke correlated myths" (113-114).

- "Locust, the flutist is war medicine. Zuni warrior kachina, the Shalako, are led from town by society flute players" (Parsons 1996 [1939]:381).

- "Cicada [Locust] is supposed to have the knowledge of producing warmth. This is why the Hopi hold it in high regard. It is said that when the cicada plays its flute, warm weather arrives. Members of the Flute society pray to the cicada, among other things, when conducting their ceremony" (Lomatuway′ma et al. 1993: 421). The cicada/locust is the flute player so prominent in rock art in the Four Corners. The warmth of the return of spring after long and cold winters and the warmth of the rising sun are intriguing in this regard.

- "Weather and curing" are linked for Hopi groups. The Flute ceremony is for rain and Flute societies are associated with the Bear Clan (Parsons 1996 [1939]:118).

Through their association with leadership, war medicine, weather, rain, and curing, Bear and Spider clans and Flute societies are further joined by a connection with the Sandhill Crane Clan (the north-oriented, Crane Clan of Zuni) based on medicine.

Medicine partners: Sandhill crane and bear

I introduced Sandhill crane evidence in chapter seven (pp. 177-179). Sandhill crane remains were identified in midden 103 (block 100)(CCAC 2004). Muir (1999, 2007) reports Sandhill crane remains on the roof of the D-shaped building. Muir (1999; 2007) identified unusual bird remains found at Sand Canyon Pueblo as representative of religious activities analogous to the historic pueblos for SCP and I agree. There is a preponderance of evidence indicating that, from the littlest bluebirds to the largest owls, birds have cosmological associations in Pueblo worldview and are found in the towers and D-shaped building at Sand Canyon Pueblo. The cultural significance of Sandhill crane at Sand Canyon Pueblo is demonstrated in the following ethnographic examples:

- Sandhill crane is a medicine partner with the Bear Clan [Zuni] (Cushing 1920:29).
- Bear and Crane are medicine partners who become "Holders of the Wand" that "bring snow of winter and are potent to cure disease which come with them"(Cushing 1920:29-30).
- "The seeds of *haʼkoʻlokta noʻwe aʻwa aʼkwawe*, 'Sandhill crane all beans medicine' are removed from the pods and crushed by women of the Sandhill Crane Clan, and mixed with beans that are to be planted. This is said to cause the bean crop to be as abundant as the seeds from the pods used in the *Powamuy* ceremony as a kiva crop. This medicine belonging to the Sandhill Crane clan" [Zuni] (Stevenson 1915:85).
- Sandhill Crane is associated with "Rain Bird" Katsina and "comes only with continuous rain (Henderson and Harrington 1914:46 in Muir 1999:120). Also associated with harvest and as guardian of harvested corn and "bringer of seeds" (Tyler 1979:128-129 in Muir 1999:120)

The historic connection between the Badger Clan ownership of *Powamuy* ("the Bean ceremony") in February provides a context where the bean kiva crop of the ceremonial kiva during February is managed by both Bear and Sandhill Crane members (see footnote 49, chapter 6), the logical place for this to occur would be in a sun-watching kiva. Sandhill crane medicine is identified as *Thelypodium wrightii* A. Gray subsp. *wrightii* (Wright's thelypody)(Stevenson 1915:84). Although these seeds were not identified at Sand Canyon Pueblo to date, the minute size of the seeds would impose subsampling bias on their capture and interpretation, falling as they most typically would into the smallest of subsampled light fraction screens. The use of a mortar and pestle would be the obvious choice for crushing the seeds due to seed size for "Sandhill Crane all beans medicine." *Powamuy* beans and planting suggest that the mortars in block 200 and 500 could serve that purpose. Evidence of beans in kiva 102 and in roof deposits elsewhere, suggests that the final attack occurred after the harvest of beans or use of dried beans. Either way, beans were available at Sand Canyon Pueblo in the context of the final attack and were either fresh or stored. Sandhill crane remains located only in block 100 and the roof of the D-shaped building are unusual.

Lastly, the intriguing presence of *tchamahia* at Sand Canyon Pueblo finds its use in ethnographic war-related contexts. *Tchamahia* are an archaeological mystery that appears to be related to war themes (LeBlanc 1999). Relatively useless as agricultural tools due to the less than durable slate-like stone from which they are made, the same lack of utility applies to the artifact as weaponry. The ethnographic record of *tchamahia* informs of its utility in ritual and in associations with War Brothers and religion.

Cactus pickers, warrior brothers, and ancient rain knives: tchamahia

Like the "rain bird" reference to Sandhill Crane Clan, the "rain knives" or *tchamahia* of Zuni (Parsons 1996 [1939]:333) are documented on the *Powamuy* altar at Orayvi (221). At Taos Pueblo, the War gods are recorded as *hayunu'* translated as "stone men, two brothers" (Parsons 1996 [1939]:Table 2). The stone men reference is intriguing in connection with the *tchamahia*, described as ancient "stone hoes" of "stone hoe people" recorded also as the "dim Stone people called Chamahia who lie on altars or are invoked in rituals" (211). "The War gods are identified with Chamahia" at Acoma, Sia, and Santo Domingo Pueblos and fetishes of the same are dressed with feathers and beads placed on altars and featured in ceremonies to install Acoma War chiefs (194). "A Santo Domingo who has served four times as War captain representing Oyoyewi, the younger War god brother, bears the honorific title of *Tsamahi'a*" (194). War captain initiation ceremonies feature buckskin fetishes with feathers called *Tsamsai'ye* and *Tsamahi'a*, arrowpoints, stone fetishes, and a large stone mountain lion also figure prominently at Zuni (594). In chapter six, I recorded the Zuni Ancient Moon-Woman Cactus Picker dance as described by Cushing (1920), an example of "the personified conflict between the wild fruits of the nomadic Zuñis and the cultivated harvests of their sedentary descendants" where the cactus with its "warlike spines" holds a "place in the *martial priesthood of plants*" (240-241; emphasis added). The themes of war include the cactus spines, the use of *Cleome* after the Cactus-picker dance used presumably for its analgesic potential is ejected over the whipped dancers of the Cactus fraternity providing tangible clues to clan and war based activities. At Sand Canyon Pueblo a miniature *tchamahia* was found in kiva 102 and full sized *tchamahia* in west blocks 200 and 500 and east block 1200.

Ellis (1967) paints a more elaborated picture of the *tchamahia* by surveying historic ethnographies. A selection of her findings is presented in Table 12.5.

Table 12.5 Northern southwest *tchamahia* and documented symbolism (compiled from data provided by Ellis [1967]).

Description	**Context and associations**	**Source**
Acoma		
"Mesa Verde *tchamahia* without banding"	Acoma recognize two types of *tchamahia*. The unbanded type is called *giap* (chisel).	Ellis 1967:39
Mesa Verde *tchamahia* with banding	If made of striped stone it is called *mashcra*. Both unbanded and banded are kept in a buckskin bag or ceremonial jar and belong to Pumpkin, Eagle, Yellow Corn, Bear, Sun, and Antelope Clans.	
	A single *tchamahia* is placed on the Kapina Society altar and said to "provide strength for warriors." It can be substituted by a decorated completely kernelled ear of corn.	Parsons 1920:119 White 1943:309

continued…

Table 12.5 Northern southwest *tchamahia* and documented symbolism (compiled from data provided by Ellis [1967]) continued.

Description	Context and associations	Source
Hopi		
Hornstone, some painted	Thought to have been brought by immigrants from Mesa Verde. The "largest example known to Dittert (1959) appears in a ceremony which 'cuts the wind,'" indicating that it is considered a knife or blade.	Dittert 1959:563-564 Ellis 1967:39
Hornstone celt from ruins in the upper San Juan area	18 *tchamahia* decorated with prayer feathers are noted for the Walpi Pueblo Snake Dance Antelope altar sand painting. According to Fewkes (1902) the word, *tchamahia* means "ancients," and the objects are "said to represent the Mountain Lion clan of the Snake phratry." The Snake clan (Keres people from Navajo Mountain) was one of the earliest clans to come to Hopi in the 13th century when many tribes were amalgamating at Hopi (Ellis 1967:37). The Snake clan is associated with warfare. Their weapon of war consisted of battle axes and clubs rather than spears, bows, and arrows. They were very fearsome, grabbing enemies by the throat and hitting them on the head with their weapons (37). This warrior society was closely associated with the Hunt Society and, like the Hunt societies in all the pueblos they were associated with the mountain lion. At Zuni, the Hunters Society was considered a warriors' society and its members could *not* be inducted into the Bow Priesthood as they already belonged to a warrior group (38).	Ellis 1967:36 Fewkes 1900a:589 1900b:189 Fewkes 1902:489 Ellis 1967:37-38 Stephen 1895 in Parsons 1936b:713-714
10 inch yellow jasper celt	1 *tchamahia* "concealed within an elaborately arranged and decorated bundle of eagle tail feathers" and considered to the be most sacred article (*tiponi*) was placed on the Mishongnovi Antelope Society altar.	Dorsey and Voth 1902:210 Ellis 1967:36
	A *tchamahia* was placed on the Snake altar and functioned to present the weapons of the "sacred Warrior Twins and, at the same time, symbolizing the mythical Stone People of the four directions." Stephens called them "hoes," the Hopi did not. The Hopi Snake Priest of the Underworld is known as *Chama'hia*, "the spiritual chief of the Snake people."	Ellis 1967:36 Stephen 1936:625, 706 Colton 1949:81 Ellis 1967:36
Laguna		
"Elongated stones" or "Mesa Verde" *tchamahias*	Most clans at Laguna Pueblo own one or two *tchamahias*. Medicine men are noted as owning some "Mesa Verde" *tchamahias.* When at Laguna, Franz Boas was told that *tchamahia* were originally human beings. Also record as being "clan children of stone, not worked into shape but just found in the mountains"	Ellis 1967:39-40
Santa Ana		
	Supernaturals of graded rank are invoked by their names, *Tcamahia, Umahia, Tsarahuyo, and Chumaikora*. *Tcamahia* [sic] and eight assistants of the War Captain are referred to as *Tchamahia*. "Whenever the Hunt Chief needed aid, he went to the War Chief and the *Tcamahia* were put as his disposal." A man who has served eight times as *Oyoyewi,* the younger of the two war gods (also the second War Captain) "receives the courtesy title of *Tcamahia.*"	Ellis 1967:40
Santo Domingo		
	A man who has served four times as *Oyoyewi*, the younger of the two war gods (also the second War Captain) "receives the courtesy title of *Tcamahia.*"	Ellis 1967:40

continued…

Table 12.5 Northern southwest *tchamahia* and documented symbolism (compiled from data provided by Ellis [1967]) continued.

Zia		
"Mesa Verde" celt *tchamahias*	Kept in ceremonial rooms used by an "upper order" religious society. At Zia the people addressed their prayers to the warrior spirits of the six directions as *tchamahia*.	Ellis 1967:40
Zuni		
	A *tchamahia* is placed on the Rain Chief's altar.	Ellis 1967:36 Stevenson 1904:xxxiv

Parsons (1936:333) first describes *tchamahia* as Hopi "rain knives," weapons "representing warrior spirits from an earlier age turned to stone" (Ellis 1967:36). The "stone hoes" of ancient stone people appear to be a misnomer for the objects. As noted in Table 12.6, Stephens called them "hoes" but the Hopi did not recognize them as such, rather as symbolic weapons or Stone people (Ellis 1967:36). The association of the object with the elder and younger warrior brothers provides additional support for a clan-based social organization at Sand Canyon Pueblo.

Chaco Canyon: "stepping into the same river twice"

I have outlined multiple lines of evidence that demonstrate a purpose-built occupation at Sand Canyon Pueblo with its foundations rooted in the same cosmological themes as historic Pueblos. The archaeology is strikingly congruent with historical religious practice, social organization, and a worldview of reciprocity. Its failure, and that of other late 13th century Mesa Verde villages, I argue, is a break in the social order that propels a further elaboration of reciprocal values in the historic Pueblos encoded and transformed for good in mythic time. Sand Canyon Pueblo mirrors that of Pueblo Bonito both in architectural plan and traumatic history. In its essentials, these sites are testament to a story of trauma where ideology and failures of leadership change social conditions and create and recreate vulnerable and less vulnerable populations. "The point then," to use Heraclitus (ca. 500 B.C.E.), is that try as we might we do not "step into the same river twice," although the essential nature of experience remains the same. The metaphoric river "of ideas" compacted into the built landscape of Chaco Canyon is not the same at Sand Canyon Pueblo, although its essential nature is. Some essence of this braided stream of metaphoric ideas continues into the historic and contemporary present.

The human effects of trauma point to a series of reconfigurations and transformations as people act to justify and reimagine their vulnerability to one of control. In the 16th century, diarist Montaigne writes of "how to live well" from the perspective of a wealthy aristocrat who found a way through his own traumatic experience through writing and questioning. We see a similar response to traumatic concerns in Ancestral Pueblo. Living well makes living tolerable where towers and walls may not be enough. Central to such vulnerability is the remembering and reconfiguring of the intolerable and the largely unresolvable. Such trauma as drought, war, disease, and death take their toll. Social arrangements shift to respond. The borrowing of Chacoan architectural forms at Sand Canyon Pueblo is more than a simple stylistic strategy or a coincidence. It is an attempt to use the past to imagine a better future.

Collapse: crises of ideology and cultural configurations in the historic period

Hereditary chief, Edmund Nequatewa (born ca.1880 into the Sun Forehead Clan) told Alfred Whiting in 1942 that at the time of the Pueblo Revolt against the Spanish in the late 1600s, the Bear Clan was "always the head of the towns in Hopi country" (Seaman, ed. 1993:14).[145] The Hopi War Brothers narrative may differ in aspects from the Zuni version but the players and themes are stable. Migration traditions tell of rifts and fissions between clans through time conceived of as a rebalance in the social order. As Whiteley (1988, 1998) describes it, failures of people to behave appropriately are central themes in Pueblo worldview. There is evidence of violence between clans in the narrated past. The focus in this selection below is reprinted here from Whiteley (1988, 1998) and details the Bow Clan's power and the change in leadership in the Fourth World. The passage also illuminates how trauma plays into mythic justifications for changes in leadership:

> The *Awatngyam*, 'Bow clan,' in Orayvi (its only village location in recent history) was powerful. In one tradition, this clan held overall chieftainship in the 'third world' below. Owing to systemic corruption, that world was abandoned (e.g. Voth 1905b:16-26) and upon emergence to the 'fourth world,' the Bow ceded leadership to the Bear clan. Historically, Bow was also the preeminent clan at Awat'ovi, 'bow on top village,' until its destruction by internecine attack from other villages in 1700 (e.g., Montgomery et al. 1949; Whiteley 1988:22).
>
> In Orayvi the Bow clan controlled prominent ritual knowledge. According to my consultants, this clan first organized *wiimi*, the 'higher-order ritual system;' previously, ritual sodalities had practiced, but without the efficacy achieved by Bow clan systematization. This refers especially to *Wuwtsim*, a ritual complex conducted by four sodalities: *Aa'alt*, 'Two-Horn;' *Kwaakwant*, 'One-Horn;' *Taatawkyam*, 'Singers;' and *Wuwtsimt* (untranslatable). I have argued for the surpassing

[145] Seaman (1993) records the following information about Nequatewa: His mother was Crane Clan and inherited the Crane Clan house at Shipaulovi village (Second Hopi Mesa) which made her responsible for the One Horned Society. When he became chief, Nequatewa became the chief of the One Horn Society (and Crane Clan). His father was a medicine man (167-169). The mythic connections between the Bear clan and Crane clan as medicine partners noted in Cushing (1920 [Zuni]) are intriguing in this respect. Nequatewa records that a rebellion incited by Bear Clan people lead to the death of Hopi prisoners by the Spanish during the revolt. This led to a Strap Clan man being chosen as leader and additional defensive building on the mesas (15.) The One Horn society is *Kwaakwant* (Whiteley 1998:221 *n*5), a First-Order Society equal in social significance to *Aa'alt*, owned by the Bow Clan (135). The connections between Bear-Crane-Bow further support a Bear-Bow connection in the D-shaped building based on the Bear effigy in block 100.

> sociopolitical importance of these sodalities. The Bow clan 'owned' *Aa'alt*, and curated its central sacra, the *Alvongya*. The *Aa'alt* held a superordinate role within *Wuwtsim;* one older consultant characterized them, in English, as the 'philosophical society' with specialized insight into 'psychology, emotionalism and individual ambitions.' Only the *Aa'alt* were allowed unrestricted access to the other three sodalities' private rituals, and thus only they are regarded as formally comprehending and supernaturally coordinating the whole ritual scheme (cf. Titiev 1944:137)(Whiteley 1998:134-135).

In Nequatewa's telling of the Pueblo Revolt at Shipaulovi, the Bear Clan also gave up power (Seaman 1993:14-15). This "ceding" of leadership may be expressed too in the archaeological record. The unclaimed bear effigy at Sand Canyon Pueblo provides clues as to a crisis of ideology that in retrospect looks like a crisis of leadership reconceptualized into one mythologized as "ceding" of leadership. The durability of leadership change through acts of "backing down" suggest that at Sand Canyon Pueblo something did back down, as evidenced in the abandonment of buildings. The final attack leaves a clan effigy exposed and its house in tatters. The "discarded" bear effigy also signals an attack not obviously initiated by Bear "people." Traditionally, such significant objects are passed down. The fact that the effigy is stone attests to its durability not only as material culture but also as a container for concepts of leadership as concrete, discrete, and meant to be seen. The stone does not change, but is an object *of* change. Unlike the wooden images of the dangerous War Brothers, the stone Bear is not meant to be invisible.

Data from the human remains analysis (Kuckelman and Martin 2007) indicate that the people who perished in block 100 were also abandoned. Their bodies remained in place, unburied and apparently unclaimed. Unlike the "carefully placed" infant in the great kiva peripheral room (813), the baby, the adolescents, the young fragile woman, and the robust six-toed man in block 100 were left without obvious funerary attention. It is probable that the Mesa Verde area was too dangerous for return, although evidence indicates that people did return, at least to bury some. The transformation in use of the D-shaped building in the last months or years of occupation and a similar condition in block 1200 looks like the collapse of a warrior group "ceding" a leadership role; certainly as depleted warrior group is plausible. Whether the highly successful raid served as retaliation or, as equally possible, the result of enraged others, the face of ancestral Mesa Verde changed. Like the reorganization of Orayvi in 1906, as described by Cameron (1992), Sand Canyon Pueblo too, appears to have suffered an ideological crisis resulting in significant numbers of its population leaving. Speculating on the social significance, the historical equivalent of village leadership, the *Qaletaqmongwi* (War Chief) may have left behind a *Kikmongwi* or village chief (Whiteley 1998:89-90 [Hopi]), ill prepared to fend off an attack by invaders, known or unknown.

The architecture of Sand Canyon Pueblo and its rich material culture not only makes a case for clan organization analogous to historic Pueblos, but also solidifies the significance of the plant record in interpreting such evidence. Archaeobotany is a costly business but its analysis has the potential to illuminate the deeper meanings of being human and being human within a culture defined by its relationships with plants. In the case of the Pueblos this relationship finds its way into finer and finer scales of meaning.

Chapter summary

The legal acceptance of oral tradition as legitimate and reflective of indigenous rights and claims brings to bear an ethical responsibility for archaeologists to use ethnographic histories and oral traditions in their interpretation of ancestral sites. There are reasons for hesitancy, however. Many oral traditions are, or appear to be, dissimilar and confusing to the uninformed. The anthropological understanding of cultural themes requires significant research investment, one that adds to the costs of archaeology, already burdened with shrinking budgets. Myth and narrative demonstrate what indigenous peoples have known for centuries, which is that their values and their traditions have time depth and are embedded in the archaeological remains of their ancestors and their ancestors' villages and encoded in oral tradition. The core "ideational complexes" described and elaborated by Whiteley (1998) for Hopi language are contained in such things. By approaching the archaeology as evidence of religion and ethos, a dataset of mythic connections emerges. In making a case for clan, I privilege tradition and ethnography not because legal precedent supports these sources, but because it has always made sense to do so.

The durable and ubiquitous themes of Pueblo religion, reciprocity, acceptance and transformations are marked on stone in art and architecture and evidenced in material remains. A preponderance of material preserved at Sand Canyon Pueblo mirror the cultural congruencies of Pueblo clan structure~~,~~ clan medicine, and curing. Human trauma and its intergenerational effects can be seen in the defensive strategies employed at Sand Canyon Pueblo and ultimately those employed on the collapse of its occupation, making leaving Mesa Verde a logical and curative action. A typical and overarching response to such conditions can be seen in the mythologizing of trauma as a method of banished memory and a reconfiguration of the original story of traumatic events to ones of resolution and a better life. These responses can be seen in the persistent reciprocal themes of Pueblo religion and the transformative effects of medicine. The archaeobotany of Sand Canyon Pueblo, though explored through limited analysis is mitigated by a holistic approach to the material culture, the fundamental basis of which can be viewed as plant-dependent in ways more deeply meaningful.

Chapter 13 Conclusions

This research began with a critical analysis of a specific method of sampling used at the Sand Canyon Pueblo site for the recovery and analysis of ancient plant remains. In two studies I have demonstrated that “species” loss is imposed through the use of the species-area methods and their reliance on the idea of redundancy and asymptote (as redundancy). The wild plant record and worked materials are the most vulnerable. Sampling strategies that aim to provide representative samples of ethnobotanical information are unable to achieve this goal because “redundancy” of information is impossible to quantify and qualify for archaeobotanical deposits and artifacts. There are reasons why this is so. Archaeologists acknowledge that the “universe” in which we work does not meet the strict criteria of sampling laid out in traditional statistical and sampling strategies. Thus, “redundancy” is an unreasonable, although clearly desirable, standard. We cannot sample to redundancy unless we know where redundancy exists.

Interpretative potential is likely jeopardized. The archaeobotanical record is jeopardized suggesting we can get by with less investment, a cautionary statement if there ever was one (if we can get by on less effort, we cannot expect to see reasonable funding or increases in funding). While archaeology is a science with finer and finer scales of effects, many of which are unpredictable and unknowable, it is a science in search of “meaning,” a meaning that originally “render[ed] endurable” the unpleasant costs of human life (Geertz 1957; Ortiz 1972:136). The data reflect a cultural concept of being and enduring. New approaches need to acknowledge this reality. Therefore, my research also addresses meaning—how we identify meaning through interpretation of archaeological remains. I show that at Sand Canyon Pueblo an enhanced understanding is possible if we delve deeper into the material culture of the site and explore how descendant oral tradition encodes and retains social memory over deep time.

Recommendations I present here could provide some resolution to some of the problems of archaeobotanical sampling bias:

More experimental testing of methods is a way we can come to understand where method choices could impose potentially unexpected constraints. An example is the bucket approach to flotation.

The bucket approach to flotation *by pouring off* the lighter material vs. skimming off light fraction introduces an abundant sediment load to individual samples. Depending on the particle size, increased volume then creates a subsampling burden. In combination with screen sorting, the smallest screens become unmanageable in terms of subsampling effort (hence the SAC approach). My sampling experiments provide evidence that retained sediment creates a microscopic overload that constrains the effectiveness of the SAC subsampling approach. Skimming off the light fraction is likely to produce less sediment.

Using the riffle box method of sample splitting prior to flotation or, alternatively, after flotation but prior to any light fraction screening, would mitigate for some of the retained debris associated with flotation samples (see Pearsall 2015). Splitting the light fraction into manageable volumes so no subsampling is imposed and providing detail in written reports could either mitigate the effects of bias on the smallest seed sizes—in actuality, the ancient wild plant record, or make clear to others what was done or left “for later” in the interpretation. This would even the playing field somewhat by not privileging larger (and potentially only “domesticated”) plant remains as long as all particle sizes receive equal attention.

A deeper focus placed on “rare” rather than common remains is advisable. Numerous researchers have demonstrated that wild plant use was not an adjunct to domesticates (Fry and Hall 1975; Hall 1979; Minnis 1981, 1989; Reinhard 2006; Stiger 1979; Sutton and Reinhard 1995) and that wild plants were a common element of consumption that persisted into the historic period. An appreciation of the wild plant record as major contributors to the diet and to the cultural mitigation of human disease, illness, injury, birth, and in mortuary practice, opens the door to a more realistic and empathetic representation of the lives lived by “archaeological” people. Wild plants are featured in all these human concerns.

The designations of “common” and “rare” are reified at Sand Canyon Pueblo due to sampling effects imposed by the subsampling method. We need to be clear in how we distinguish the category, “rare.” Rare remains offer an entry into less common practice. I have shown that certain plants deemed “rare” to Sand Canyon Pueblo and Locality sites may be the result of sampling *and social context*. In the case of ethnographic evidence of less common plants such as *Cycloloma* that were traditionally used in preparation for war, is an example of contextual significance for understanding food and a deeper reality. To this end I provide evidence that Ancestral Puebloans at Sand Canyon Pueblo very plausibly used plants for medicines and that knowledgeable individuals would have been aware of the toxic and healing effects of the plants they selected. This knowledge would have been gained through experimentation, culturally specific scientific inquiry, testing and re-testing. The ethnobotanical record clearly indicates treatment options for particular diseases and health conditions. A synthetic approach to a range of historic documentation and material culture has allowed me to situate clan medicine at Sand Canyon Pueblo. Wild plants have much to offer in terms of interpretative potential, food being only one aspect of the challenges we all face as human beings where the spectre of disease and war can pose equal, if not more serious immediacy than subsistence concerns. Pueblo III populations were not entirely passive victims of their ecological and social environments. They retained the diverse diet breadth of their archaic ancestors and were responsive to the challenges of living under drought conditions. Pueblo people have integrated their communities in terms of clans and societies in what might seem novel to the unfamiliar, certainly not to the descendants. These strategies for social cohesion have proven clearly durable and effective for mitigating boundaries between people and encouraging cooperation and respect. The fundamental basis for such organization exists within a durable value system that arose in the Pueblo past. Understanding such complexities requires attention to small remains and "outliers" to fully appreciate the nature of the archaeological record and to evaluate subsistence, adaptations, and change.

Regardless of processing and subsampling strategies, first and foremost, the context in which samples are collected are key to interpretative potential of archaeobotanical remains. Little can be said of resource change if the context lacks time depth. In my opinion it is an unreasonable expectation that we would see diet change at Sand Canyon Pueblo. A thirty year occupation on rock is a challenging stratigraphy, if visible at all. To investigate the effects of subsistence stress we must consider a number of factors, invisible stratigraphy being one. If the drought that hit hard in the A.D. 1270s was unmanageable, people would have left of their own accord *en masse* prior to the final attack (if there was more than one). The human remains at Sand Canyon Pueblo testify to a people annihilated or driven out. The people were well aware of the nature of the environment in which they lived and had experienced drought personally and/or through cultural memory. Limited excavation clearly impacts how well we can speculate on last day population numbers and how depleted the population was prior to the final attack. Hearth contents from only partially excavated residences run the risk of capturing evidence of "absence" that is troublesome to interpret and can contribute to interpretative distortions. Without knowing to a greater degree just how "abandoned" Sand Canyon Pueblo was, hearth contents could speak to an abandoned kiva, a non-representative sample, or a well-cleaned hearth. The timing of abandonment in relation to the typical preparation of food is a fact that must be considered—pre-meal, post-meal—these basic human realities are significant. To resolve such issues, a wider sampling universe is required. Limited excavation may serve to provide archaeological stewardship but impacts interpretative potential to the point of tipping the balance of such stewardship into the realm of *non-stewardship* of the record. In this respect we are affording more attention to the overburden than the site. To misinterpret without hope of additional data does not serve the discipline, the research, or the descendants well.

Sand Canyon Pueblo is important archaeological and ancestral treasure, a fact that archaeologists and descendants are keenly aware. The site is even more so in light of the North

American Graves Protection and Repatriation Act, *Delgamuukw*, and challenges by descendants for a stronger voice in decisions and interpretations of their ancestral history and under the on-slaught of pot-hunting and illegal artifact trading. The site has much to tell us about the ancestors, and we have much to learn from them. But, these people are not *my* ancestors. The decision to excavate further must rest with descendants. In defense of archaeology, I firmly believe that excavation limits unlawful destruction and disturbance. Pot hunting and illegal artifact trade are crimes against human history, the ancestors, their current descendants, and ultimately their descendants to come. Despite our differences, descendant and non-descendant, we share a sense that archaeological sites hold lessons to be learned. They also should facilitate a common respect for the "other," the dignity of the past, the people of the past, and the material remains of the past, although reconfigured within our different "cultures" and personal visioning. The wanton destruction of archaeological sites in the Middle East today only reinforces the importance of protecting this legacy.

The problem of sampling and subsampling in archaeobotany reflects the challenges in underrepresentation of many artifact classes in archaeology—a fact confronted by many. Before giving up hope of understanding the material remains of ancestral culture we must first attempt to understand the voices of contemporary and historic descendants. From a purely ethical perspective we must assume first, that when Pueblo people say they are descendants, we accept this to be true; and that their histories, regardless of form, have legitimacy; and that we may not understand without contemplation and confrontation of our own subjectivity. Through the work of symbolic anthropologists, ecologists, and archaeologists, cultural keystones and key symbols provide additional support for the anthropological realities of human beings. The durability of these themes has been shown to reside in the nature of social memory and the practice and retelling of oral tradition. To this end, my work aims to privilege ethnographic congruencies with archaeological remains through the rich repository of tradition, ceremony, practice, and language seen in Pueblo culture today and in the historic period. As archaeologists, we have more to offer in terms of aligning research within what we understand *could be* Pueblo ways. Descendants, if they are willing, can then tell us if we are on track, out of line, or just merely voyeurs. Whatever the case, I have a deep respect for the values of Pueblo culture, both today and in its various configurations in the past. In our new and challenging times, these and ancient voices have much to offer as cautionary evidence if we do not re-balance our priorities.

The species-area curve approach is a poor fit for archaeobotany at Sand Canyon Pueblo because of the overburden of retained debris through the method of flotation and the use of screening first and splitting later. The foundations of the species-area curve approach however, are firmly embedded in *patterns* that can be recognizable. Science and mathematics use the concept of asymptote (a line that does not meet another line in a very particular way) to talk about living species richness and diversity because they plot data randomly and use huge datasets. The species-area curve approach used here is a collector/accumulation curve method that when plotted, shows that "asymptote" is an artifact of the sampling process. In most cases, although not all, it indicates that sampling/subsampling must continue, confirming Arrhenius' (1921) data: if you sample more you find more (*the* species-area relationship). Those things "anthropological," such as human decisions and resultant material remains, are also evidence of patterns. I have shown that the patterning of data tell us something about the biases of archaeological interpretation. Capture the "outliers" in analysis can yield significant interpretative potential. Such things as the rare plants (or, rarely identified plants, and the artifactual "outliers" such as an effigy, a rectangular pottery box, and the language of ideograms and architecture) creates real potential to bring deeply meaningful ancestral phenomena to light. The cultural patterns are clear at Sand Canyon Pueblo. The ethnographic record is a richly elaborated place for future consultation. My argument for clan and clan medicine is strong because of the ethnographic and ethnobotanical records and the gracious sharing of Pueblo people. Sand Canyon Pueblo shows in its many aspects, a traditional ideology that has persisted in recognizable form since at least late Pueblo III. It may not be quite the same "river," as Chaco Canyon or the historic period of Pueblo but it contains much of its essence.

Although my research is not "about" Hopi or Zuni, I cannot ignore the underlying values with which Hopi, Zuni, and other Pueblo peoples view their worlds. Emergence narratives tell us that the Pueblos are amalgams of many clans that came together under the auspices of providing important contributions to the villages in which they eventually settled. This occurred in mythic times and, there is no doubt through time, persisted after the people left Mesa Verde. The keystones of these relationships are founded on cultural modes of reciprocity—the balancing and re-balancing of natural and existential "environments." I am most grateful to Peter Whiteley, whose exceptional writings of Hopi life and language and his recommendation to view the archaeological record from the point of view of local theory, are well taken. I hope they are well-executed here.

In 1999, Michael Rosenzweig wrote of the ecological species-area relationship that "if, in the long run, *area* is the true prime mover on which diversity depends, we should reevaluate how little emphasis we place on it" (277; emphasis added). The collapse of species diversity, never greater than in today's "present," threatens to reorganize the biosphere in ways we cannot imagine. Many will be, if not already, in the unfortunate position of having to adapt under its onslaught. We have evidence of a similar trauma demonstrated through archaeological research. The same is true of indigenous cultures with their long history of loss and forced adaptation. Sand Canyon Pueblo is a container that shares that history. In reality, it is the *effects of culture* that are the prime mover on which all diversity depends. Indeed, we would do well to reevaluate the emphasis we put on our own cultural effects. If limited sampling constrains analysis then the concept of stewardship of the archaeological record is called into question. The archaeological is proof positive of durable and effective cultural approaches to ecological and social problems.

I have provided new data for the archaeobotanical record of Sand Canyon Pueblo and a new explanation for the material remains of the site. Archaeology is driven by alternative explanations, and in this work I have revisited Sand Canyon Pueblo from an ethnographic lens, a “local” theory of what Sand Canyon Pueblo signifies if it was a historic pueblo, and found that the evidence is congruent with local Pueblo history, confirmed by contemporary practice and social roles, and underpinned by enduring social memory. These were people who have persisted, we would do well to learn more from them. The next step is to move the analysis out of the laboratory and into the “field,” by offering these explanations to descendants, if they choose to engage. To understand the past is always to negotiate the pitfalls of disturbing it.

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Appendix A: Experimental study data

Table A.1 Control sample reproductive parts: one litre total bulk volume, dry screened, all examined. Designations conform to USDA NRS (2015). Species identified at the genus-level, some species identified on site (early spring).

Family	**Genus**	**Species**[a]	**Common name**	**Confidence level**[b]	**On site**
Asteraceae/Compositae (Aster/Sunflower)	*Artemisia*	*absinthium* L.	absinthe/wormwood	T	present
	Balsamorhiza	*sagittata* (Pursh.) Nutt.	arrowleaf balsamroot	A	present
	Centaurea L.	*diffusa/maculosa*-type	knapweed (diffuse/spotted)	T	not observed
	Lactuca L.	-type	lettuce (wild)	A	not observed
	Tragopogon L.	-type	goatsbeard	A	present
Boraginaceae (Borage)	*Cynoglossum*	*officinale* L.	hound's tongue/gypsy flower-type	A	present
Brassicaceae/Cruciferae (Mustard)	*Lepidium*	*densiflorum* Shrad.-type	common pepperweed	A	present
	Lepidium/ Cardaria	*draba* L./draba (L.) Desr.-type	whitetop	T	present
	Sisymbrium	*altissimum* L.-type or	tall tumblemustard	A	present
	Sisymbrium	*loeselii* L.-type	small tumblemustard		present
	Thlapsi	*arvense* L.-type	field pennycress	A	not observed
Caryophyllaceae (Pink)	*Silene*/*Lychnis*	*coronaria* L.-type	catchfly/campion-type	A	present
Chenopodiaceae (Goosefoot)	*Chenopodium* L.	-type	goosefoot	A	not observed
Fabaceae (Pea)	*Medicago*	*lupulina* L.	black medick	A	present
	Melilotus	*officinalis* L.	white sweet clover	A	present
Lamiaceae/Labiatae (Mint)	*Dracocephalum*	*parviflorum* Nutt.	American dragonhead	A	not observed
Poaceae/Gramineae (Grass)	*Agropyron* Gaerth.	-type	wheatgrass	A	present
Polygonaceae (Buckwheat)	*Polygonum*	-type	knotweed	A	not observed
Scrophulariaceae (Figwort)	*Verbascum*	*thapsis L.*	common mullein	A	present

Notes:

[a] –type designations account for those plants that are similar to genus or species but allows for latitude for error

[b] T: tentative identifications are identified by the letter "T"; confidence level "A" reflects that the plant is more likely the one identified than another genus or species.

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery summary and 100 per cent survey results. Listed by light fraction screen size and order of recovery. All exotics identified in bold print. Species-area curve results shaded. All subsamples contain roots, twigs, insect parts and pellets (undocumented).

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
Exotic recovery summary light fraction									
4.75	***Phaseolus vulgaris***	**common bean**	**a**	**whole intact**	**a**	**no**	**c**	**2**	
4.75	***Phaseolus vulgaris***	**common bean**	**a**	**cotyledon**	**a**	**no**	**c**	**2**	= one specimen
4.75	***Tropaeolum***	**nasturtium**	**a**	**seed**	**a**	**no**	**c**	**1**	
4.75	***Zea mays***	**maize/corn**	**a**	**caryopsis**	**a**	**no**	**c**	**1**	
4.75	***Lagenaria siceraria***	**bottle gourd**	**a**	**seed**	**a**	**no**	**c**	**1**	
4.75	***Cucurbita***	**squash**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Secale cereale***	**cereale rye**	**a**	**caryopsis**	**a**	**no**	**c**	**2**	
2.8	***Phaseolus vulgaris***	**common bean**	**a**	**seedcoat**	**a**	**yes**	**c**	**3**	
2.8	***Trigonella foenum-graecum***	**sicklefruit fenugreek**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Lathyrus latifolius***	**perennial pea**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Piper nigrum***	**black peppercorn**	**a**	**fruit**	**a**	**no**	**c**	**1**	
2.8	***Piper nigrum***	**black peppercorn**	**a**	**fruit**	**a**	**no**	**c**	**1**	
1.4-2	***Chenopodium quinoa***	**quinoa**	**a**	**seed**	**a**	**no**	**c**	**1**	
1.4-6	*Phaseolus vulgaris*	common bean	cf	seedcoat	cf	yes	c	1	
1.4-8	*Phaseolus vulgaris*	common bean	cf	seedcoat	cf	yes	c	1	
.71-5	*Rosmarinus officinalis*	rosemary	a	seed	a	no	c	1	
.71-6	*Salvia hispanica*	chia	a	seed	a	no	c	1	
.71-7	*Ocimum basilicum*	sweet basil	a	seed	a	no	c	1	
.71-14	*Melissa officinalis*	common balm	a	seed	a	no	c	1	
.25-7	*Origanum vulgare*	oregano	a	seed	a	no	c	1	
.25-19	*Portulaca*	purslane	a	seed	a	no	c	1	
.25-23	*Mentha*	mint	a	seed	a	no	c	1	
.25-24	*Mentha*	mint	a	seed	a	no	c	1	
.25-28	*Mentha*	mint	a	seed	a	no	c	1	
.25-46	*Borage* (cf)	tissue	t	tissue	t	yes	c	1	not included in count†
Total unique exotics recovered								**17**	
Heavy fraction (quick scan)								**Nil**	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
4.75 mm light fraction screen (no subsampling applied)									
4.75	*Lepidium densiflorum-type*	common peppergrass	a	pod half	a	no	u	1	
4.75	***Phaseolus vulgaris***	**common bean**	**a**	**whole intact**	**a**	**no**	**c**	**2**	**new exotic**
4.75	***Phaseolus vulgaris***	**common bean**	**a**	**cotyledon**	**a**	**no**	**c**	**2**	
4.75	***Tropaeolum***	**nasturtium**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Zea mays***	**maize/corn**	**a**	**caryopsis**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Lagenaria siceraria***	**bottle gourd**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Cucurbita***	**squash**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	Poaceae	grass	t	spikelet/caryopsis	t	yes	u	1	
2.8 mm light fraction screen (no subsampling applied)									
2.8	Poaceae	grass	t	spikelet/caryopsis	t	no	u	3	
2.8	***Secale cereale***	**cereale rye**	**a**	**caryopsis**	**a**	**no**	**c**	**2**	**new exotic**
2.8	***Phaseolus vulgaris***	**common bean**	**a**	**seedcoat**	**a**	**yes**	**c**	**3**	
2.8	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	achene	t	no	u	1	
2.8	***Trigonella foenum-graecum***	**sicklefruit fenugreek**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Lathyrus latifolius***	**perennial pea**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Piper nigrum***	**black pepper**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Sinapis alba***	**white mustard**	**t**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
1.4-1	Poaceae	grass	a	spikelet	a	no	u	2	(4.75)
1.4-1	*Polygonum*	knotweed-type	a	achene	a	no	u	1	new non exotic
1.4-1	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(2.8)
1.4-2	***Chenopodium quinoa***	**quinoa**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-2	Poaceae	grass	a	spikelet	a	no	u	4	(4.75)
1.4-2	*Polygonum*	knotweed-type	a	achene	a	no	u	2	(1.4-1)
1.4-2	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(2.8)
1.4-2	*Lithospermum arvense*	corn gromwell	a	seed	a	no	u	1	new non exotic
1.4-3	*Polygonum*	knotweed-type	a	achene	a	no	u	1	(1.4-1)
1.4-3	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	(4.75)
1.4-4	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(4.75)
1.4-4	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)
1.4-4	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	(1.4-2)
1.4-5	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	(4.75)
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-5	*Lithospermum arvense*	corn gromwell	a	whole seed, intact	a	no	u	1	(1.4-2)
1.4-5	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	(1.4-2)
SAC stopping point (minimal volume)									
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	4	
1.4-6	***Phaseolus vulgaris***	**common bean**	**cf**	**seedcoat**	**cf**	**yes**	**c**	**1**	**(4.75)**
1.4-6	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-6	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-7	Poaceae	grass	a	spikelet/caryopsis	a	no	u	4	
1.4-7	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-7	*Lepidium densiflorum*-type	common peppergrass	a	full pod, stem	a	no	u	1	
1.4-7	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	5	
1.4-7	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-7	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
1.4-8	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-8	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-8	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-8	***Phaseolus vulgaris***	**common bean**	**cf**	**seedcoat**	**cf**	**yes**	**c**	**1**	**(4.75)**
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	3	
1.4-9	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-9	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-9	unknown botanical	unknown	a	disseminule	cf	no	u	1	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	pod & stem	a	no	u	1	
1.4-9	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-10	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	
1.4-10	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	5	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-11	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-11	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-11	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
1.4-11	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-11	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	3	

continued…

Table A. 2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-12	unknown botanical	unknown	a	bud	cf	no	u	1	
1.4-12	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	4	
1.4-12	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-12	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-12	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-13	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	full pod & stem	a	no	u	1	
1.4-14	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-14	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-14	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	4	
1.4-14	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-14	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.71-1	*Polygonum*	knotweed-type	t	achene	a	no	u	1	(1.4-1)
.71-1	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
.71-1	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)
.71-2	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	7	(2.8)
.71-2	*Lactuca*-type	wild lettuce-type	cf	seed	cf	no	u	1	new non exotic
.71-2	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
.71-3	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	seed	a	no	u	8	(2.8)
.71-3	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	new non exotic
.71-3	*Polygonum*	knotweed-type	t	achene	a	no	u	1	(1.4-1)
.71-3	*Lithospermum arvense*	corn gromwell	a	seed	a	no	u	1	(1.4-2)
.71-3	Poaceae	grass	t	caryopsis	t	no	u	1	(4.75)
SAC Stopping point (minimal volume)									
.71-4	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes/no	u	5	
.71-4	*Polygonum*	knotweed-type	t	achene	t	yes	u	3	
.71-4	*Lithospermum arvense*	corn gromwell	a	achene	a	yes	u	1	
.71-4	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
.71-4	unknown botanical	seedcoat, ovoid	t	seedcoat	t	yes	u	1	<.71 mm
.71-5	***Rosmarinus officinalis***	**rosemary**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-5	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	achene	cf	no	u	13	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation samples 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-5	*Polygonum*	knotweed-type	t	achene	t	no	u	7	
.71-5	*Trifolium*	clover	t	seed	t	no	u	1	new non exotic
.71-5	unknown botanical	seedcoat, round	t	seedcoat	t	no	u	1	
.71-5	*Chenopodium/amaranthus*	cheno-am	t	seed	t	no	u	1	
.71-5	*Lithospermum arvense*	corn gromwell	a	seed half	a	no	u	1	
.71-6	*Centaurea* (diffusa/maculosa-type)	diffuse/spotted knapweed	cf	seed	cf	no	u	11	
.71-6	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
.71-6	unknown botanical	unknown ovate	a	seed	a	no	u	1	
.71-6	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
.71-6	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.71-6	***Salvia hispanica***	**chia**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-6	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	1	
.71-6	*Polygonum*	smartweed-type	t	achene	a	yes	u	1	
.71-7	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	seed	cf	no	u	12	
.71-7	*Trifolium*	clover	t	seed	a	no	u	1	
.71-7	*Artemisia*-type	sagebrush-type	t	flowerhead	cf	no	u	1	new non exotic
.71-7	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-7	***Ocimum basilicum***	**sweet basil**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-8	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
.71-8	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	seed	cf	no	u	22	
.71-8	Poaceae	grass	t	caryopsis	t	no	u	1	
.71-8	*Trifolium*	clover	t	seed	a	no	u	1	
.71-8	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.71-8	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.71-9	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	seed	t	no	u	18	
.71-9	*Lithospermum arvense*	corn gromwell	t	seed	t	no	u	1	
.71-9	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.71-9	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-10	*Polygonum*	knotweed-type	t	achene	a	yes	u	2	
.71-10	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	3	
.71-10	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	seed	t	no	u	14	
.71-10	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.71-10	*Lithospermum arvense*	corn gromwell	t	seed	t	yes	u	1	
.71-11	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	6	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-11	*Polygonum*	knotweed-type	t	achene	t	no	u	3	
.71-11	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	2	
.71-11	unknown botanical	unknown bud	t	bud	t	no	u	1	
.71-12	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	seed	t	no	u	17	
.71-12	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.71-12	Poaceae	grass	t	spikelet	t	no	u	1	
.71-12	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.71-13	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	t	seed	cf	no	u	8	
.71-13	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.71-13	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.71-14	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.71-14	***Melissa officinalis***	**common balm**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.25-1	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	new non exotic
.25-1	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	new non exotic
.25-1	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	(.71-3)
.25-2	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	(.25-1)
.25-2	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	(.25-1)
.25-2	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	1	(.71-3)
.25-3	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	(.25-1)
SAC stopping point (minimal volume)									
.25-4	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-4	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-4	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-5	*Silene*	catchfly/campion-type	a	seed	a	yes/no	u	19	
.25-5	*Myosotis*	forget-me-not	t	seed	a	no	u	1	
.25-5	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-6	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-6	*Centaurea (diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
.25-6	unknown botanical	seed, folded	cf	seed	cf	no	u	2	
.25-6	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-7	*Verbascum thapsus*	common mullein	a	seed	a	yes	u	2	
.25-7	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-7	***Origanum vulgare***	**oregano**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25-8	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-8	*Descurainia*-type	tansy mustard	t	seed	t	no	u	1	
.25-8	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-9	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-9	*Polygonum*-type	knotweed-type	cf	achene	cf	no	u	1	new type
.25-9	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-9	*Myosotis*	forget-me-not	t	seed	a	no	u	1	
.25-10	unknown botanical	seedcoat	cf	seedcoat	cf	no	u	1	
.25-10	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-10	*Centaurea (diffusa/maculosa*-type*)*	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-11	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-11	*Myosotis*	forget-me-not	t	seed	a	no	u	1	
.25-11	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-12	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-12	*Descurainia*	tansy mustard	t	seed	a	no	u	2	
.25-12	*Lepidium densiflorum-type*	common peppergrass	t	seed	a	no	u	1	
.25-12	*Centaurea (diffusa/maculosa*-type*)*	diffuse/spotted knapweed	cf	achene	a	yes	u	1	
.25-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	15	
.25-13	*Myosotis*	forget-me-not	t	seed	a	no	u	1	
.25-13	*Verbascum thapsus*	common mullein	a	seed	a	no	u	5	
.25-14	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-14	unknown botanical	seedcoat, round	t	seedcoat	t	no	u	2	
.25-14	*Centaurea (diffusa/maculosa*-type*)*	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-15	*Myosotis*	forget-me-not	t	seed	t	no	u	1	
.25-15	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-15	unknown botanical	seedcoat, ovate	t	seedcoat	t	no	u	2	
.25-15	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-15	*Centaurea (diffusa/maculosa*-type*)*	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-16	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-16	*Verbascum thapsus*	common mullein	a	seed	a	no	u	4	
.25-16	*Lactuca*-type	wild lettuce-like	cf	seed	a	no	u	1	
.25-16	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.25-17	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	

continued...

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-17	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-18	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-18	*Myosotis*-type	seedcoat	cf	seedcoat	cf	no	u	1	
.25-19	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-19	unknown botanical	unknown ovate	t	seed	t	no	u	1	
.25-19	unknown botanical	flowerhead	t	flowerhead	t	no	u	1	
.25-19	*Chenopodium/amaranthus*	cheno-am	t	seed	t	no	u	1	
.25-19	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-19	***Portulaca***	**purslane**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25-20	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-20	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-20	*Myosotis*	forget-me-not	t	seed	a	no	u	2	
.25-21	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-21	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-21	*Myosotis*	forget-me-not	t	seed	t	no	u	1	
.25-22	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-22	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-22	unknown botanical	seedcoat	cf	seedcoat	cf	no	u	1	
.25-22	*Myosotis*	forget-me-not	cf	seedcoat	cf	no	u	1	
.25-23	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-23	***Mentha***	**mint**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25-23	unknown botanical	seedcoat, round	cf	seedcoat	cf	no	u	1	
.25-24	unknown botanical	seedcoat, ovate	cf	seedcoat	cf	no	u	1	
.25-24	*Descurainia*-type	tansy mustard	t	seed	t	no	u	1	
.25-24	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-24	***Mentha***	**mint**	**a**	**seed**	**a**	**no**	**c**	**1**	**(.25-23)**
.25-24	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-25	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-25	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-25	unknown botanical	seedcoat, round	t	seedcoat	t	no	u	1	
.25-26	*Silene*	catchfly/campion-type	t	seed	t	no	u	9	
.25-26	unknown botanical	seedcoat, round	t	seedcoat	t	no	u	1	
.25-26	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-27	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-27	unknown botanical	seedcoat, ovate	cf	seedcoat	cf	no	u	1	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-28	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-28	*Chenopodium/amaranthus*	cheno-am	t	seed	t	yes	u	1	
.25-28	*Myosotis*	forget-me-not	t	seed	t	no	u	1	
.25-28	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-28	***Mentha***	**mint**	**a**	**seed**	**a**	**no**	**c**	**1**	**(.25-23)**
.25-29	unknown botanical	seedcoat, ovate	cf	seedcoat	cf	no	u	1	
.25-29	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-29	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-30	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-30	*Artemisia*-type	sage	t	achene	t	no	u	1	
.25-31	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-32	*Descurainia*-type	tansy mustard	cf	seed	t	no	u	1	
.25-32	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-32	unknown botanical	seedcoat, ovate	cf	seedcoat	cf	no	u	1	
.25-33	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-33	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-33	unknown botanical	unknown ovate	cf	seed	t	no	u	1	
.25-33	*Descurainia*-type	tansy mustard	cf	seed	t	no	u	1	
.25-34	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-34	*Descurainia*	tansy mustard	a	seed	a	no	u	1	
.25-34	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-34	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-35	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	2	
.25-35	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-35	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-35	unknown	black spherical body	cf	black spherical body	cf	no	u?	3	
.25-35	unknown botanical	seed, unk	t	seed	t	no	u	1	
.25-36	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-36	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-36	*Descurainia*	tansy mustard	t	seed	a	no	u	1	
.25-37	*Myosotis*	forget-me-not	cf	seed	t	no	u	1	
.25-37	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-37	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-38	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-39	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-39	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-40	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-40	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-40	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-40	*Lactuca*-type	wild lettuce-like	cf	seed	t	no	u	1	
.25-41	*Silene*	catchfly/campion-type	a	seed	a	yes/no	u	7	
.25-42	*Silene*	catchfly/campion-type	a	seed	a	no	u	18	
.25-43	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-43	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-43	*Verbascum thapsis*	common mullein	a	seed	a	no	u	1	
.25-44	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-44	*Myosotis*	forget-me-not	a	seed	a	no	u	3	
.25-44	unknown	seedcoat	t	seedcoat	t	yes	u	1	
.25-45	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-45	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-45	Poaceae	unknown	t	spikelet/caryopsis	t	yes	u	1	
.25-46	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-46	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-46	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-46	***Borago* (cf)**	**tissue**	**t**	**seed tissue**	**t**	**yes**	**c**	**1**	
.25-47	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-47	unknown	seed, round	t	seed	t	no	u	2	
.25-47	*Verbascum thapsus*	common mullein	a	seed	a	no	u	5	
.25-47	unknown	seed, ovoid	t	seed	t	no	u	1	
.25-47	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-47	unknown	seedcoat	t	seedcoat	t	yes	u	1	
.25-48	*Silene*	catchfly/campion-type	a	seed	a	no	u	15	
.25-48	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-48	unknown	black spherical body	t	black spherical body	t	no	c?	1	
.25-48	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-49	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-49	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-49	*Descurainia*	tansy mustard	t	seed	a	no	u	1	
.25-49	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-50	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	

continued…

Table A.2 Experiment 2, firepit 5 data: flotation sample 1 exotic recovery, continued.

Screen size-subsampling number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-50	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-50	*Myosotis*	forget-me-not	cf	seedcoat	cf	yes	u	1	
.25-51	unknown	seedcoat	t	seedcoat	t	no	u	1	
.25-51	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-52	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-52	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	

Notes
[a] "C" Analyst confidence: a (absolute); t (tentative); cf (compares favourably).
[b] "Frag" Fragment: yes/no.
[c] "Cond" Condition: c (charred); u (uncharred); pc (partially charred).
† specimens that would be unrecognized under normal conditions.

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery summary and 100 per cent survey results. Listed by light fraction screen size and order of recovery. All exotics identified in bold print. Species-area curve results shaded. All subsamples contain roots, twigs, insect parts and pellets (undocumented).

Screen size/ subsample number	**Scientific name**	**Common name**	**C[a]**	**Part**	**C[a]**	**Frag[b]**	**Cond[c]**	**Count**	**Notes/found previously**
Exotic recovery summary									
4.75	***Phaseolus vulgaris***	**bean fragments**	**a**	**cotelydon**	**a**	**yes**	**c**	**5**	**2 cotelydons/1 bean**
4.75	***Helianthus annuus***	**sunflower**	**a**	**achene**	**a**	**no**	**c**	**2**	
4.75	***Tropaeolum***	**nasturtium**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Piper nigrum***	**black peppercorn**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Alcea***	**hollyhock**	**a**	**seed**	**a**	**no**	**c**	**3**	
1.4-2	***Sinapis alba***	**yellow mustard**	**a**	**seed**	**a**	**no**	**c**	**1**	
1.4-3	***Physalis***	**common groundcherry**	**a**	**seed**	**a**	**no**	**c**	**1**	
.71-3	***Rosmarinus officinalis***	**rosemary**	**a**	**seed**	**a**	**no**	**c**	**1**	
.71-3	***Apium graveolens***	**celery**	**a**	**seed**	**a**	**no**	**c**	**2**	
Total unique exotics recovered								**13**	
Individual screen recovery									
Heavy fraction (quick scan)									
	Fagopyrum esculentum	**buckwheat**	**a**	**achene**	**a**	**no**	**c**	**2**	**not included in count†**
4.75 mm light fraction screen (no subsampling applied)									
4.75	***Phaseolus vulgaris***	**bean fragments**	**a**	**cotelydon**	**a**	**yes**	**c**	**5**	**new 5 fragments= 1 bean**
4.75	***Helianthus annuus***	**sunflower**	**a**	**achene**	**a**	**no**	**c**	**2**	**new exotic**
4.75	***Tropaeolum***	**nasturtium**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	*Lithospermum arvense*	corn gromwell	a	seed/achene	a	no	u	1	whole
4.75	*Lepidium densiflorum*-type	common peppergrass	a	seedcoat half	a	no	u	1	
4.75	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
4.75	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	t	achene	t	no	u	3	
4.75	Poaceae	grass	t	spikelet/caryopsis	t	no	u	4	
2.8 mm light fraction screen (no subsampling applied)									
2.8	***Piper nigrum***	**black peppercorn**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Alcea***	**hollyhock**	**a**	**seed**	**a**	**no**	**c**	**3**	**new exotic**

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
2.8 mm light fraction screen (no subsampling applied) continued									
2.8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
2.8	Poaceae	grass	cf	spikelet/caryopsis	a	yes	u	2	
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
1.4-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	6	(4.75)
1.4-1	Poaceae	grass	a	spikelet/caryopsis	a	no	u	5	(4.75)
1.4-1	*Lepidium densiflorum*-type	common peppergrass	cf	seed	a	no	u	1	(4.75)
1.4-1	*Polygonum*	knotweed-type	a	achene	a	no	u	2	new non exotic
1.4-2	***Sinapis alba***	**yellow mustard**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-2	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	(4.75)
1.4-2	Poaceae	grass	a	spikelet/caryopsis	a	no	u	4	(4.75)
1.4-2	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)
1.4-3	*Poaceae*	grass	a	spikelet/caryopsis	a	no	u	1	(4.75)
1.4-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	(4.75)
1.4-3	***Physalis***	**common groundcherry**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-3	*Polygonum*	knotweed-type	a	achene	a	yes	u	2	(1.4-1)
1.4-4	*Polygonum*	knotweed-type	a	achene	a	no	u	1	(1.4-1)
1.4-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(4.75)
1.4-4	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(4.75)
1.4-5	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	(4.75)
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	(4.75)
1.4-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(4.75)
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
1.4-6	*Polygonum*	knotweed-type	a	achene	a	no	u	5	(1.4-1)
1.4-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	(4.75mm)
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)
1.4-6	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	(4.75)
1.4-6	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	(1.4-1)
SAC stopping point (minimal volume)									
1.4-7	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	
1.4-7	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-7	Poaceae	grass	a	spikelet	a	no	u	2	
1.4-7	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-7	***Trigonella foenum-graecum***	**fenugreek**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-8	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-8	*Polygonum*	knotweed-type	a	achene	a	yes	u	2	
1.4-8	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	
1.4-8	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-8	unknown botanical	unknown	a	bud/capsule	cf	no	u	1	
1.4-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-9	*Polygonum*	knotweed-type	a	achene	a	yes	u	2	
1.4-9	Poaceae	grass	a	spikelet/caryopsis	a	no	u	4	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	cf	seed	cf	yes	u	1	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-10	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-10	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-11	***Lactuca sativa***	**lettuce**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-11	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-11	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-11	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-11	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-11	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-12	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-13	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-13	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-14	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-14	unknown botanical	unknown	a	bud/capsule	cf	no	u	1	
1.4-14	*Phaseolus vulgaris*	bean	a	seedcoat	a	yes	c	1	
1.4-14	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-14	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.71-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	12	(4.75)
.71-1	*Polygonum*	knotweed-type	t	achene	t	yes	u	2	(1.4-1)
.71-1	*Brassica*-like	mustard-type	cf	seedcoat	cf	no	u	1	new non exotic
.71-1	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
.71-2	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	14	(4.75)
.71-2	*Trifolium*-type	clover	t	seed	a	no	u	1	new non exotic
.71-2	*Polygonum*	knotweed-type	t	achene	a	no	u	1	(1.4-1)
.71-2	*Lactuca*-like	wild lettuce-like	cf	seed	cf	no	u	1	new non exotic
.71-3	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	(4.75)
.71-3	***Rosmarinus officinalis***	**rosemary**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-3	*Centaurea* (*diffusa/maculosa*-type)	"sunflower" seed	cf	seed	cf	no	u	10	(4.75)
.71-3	*Polygonum*	knotweed-type	t	achene	a	yes	u	2	(1.4-1)
.71-3	***Apium graveolens***	**celery**	**a**	**seed**	**a**	**no**	**c**	**2**	**new exotic**
.71-4	unknown botanical	unknown	t	disseminule	t	no	u	1	
.71-4	*Polygonum*	knotweed-type	t	achene	a	yes	u	1	(1.4-1)
.71-4	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	new non exotic
.71-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	11	(4.75)
.71-4	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
.71-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	11	(4.75)
.71-5	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	3	(4.75)
.71-5	*Polygonum*	knotweed-type	t	achene	t	yes	u	2	(1.4-1)
.71-5	unknown botanical	unknown, ovoid, minute	t	seed	t	no	u	1	.25 mm in size
.71-5	unknown botanical	tissue-borage-like	t	tissue	t	yes	c	1	
.71-5	unknown botanical	unknown	t	flowerhead	t	no	u	1	
.71-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	17	(4.75)
.71-6	*Lithospermum arvense*	corn gromwell	t	seedcoat half	a	no	u	1	(4.75)
.71-6	unknown botanical	unknown	t	seedcoat half	a	no	u	1	vertical ridges possible insect
.71-6	*Lithospermum arvense*	corn gromwell	a	seed whole	a	no	u	1	(4.75)
.71-6	Poaceae	grass	a	spikelet/caryopsis	t	no	u	1	(4.75)

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
SAC stopping point (minimal volume)									
.71-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	17	
.71-7	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-7	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	3	
.71-7	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
.71-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	14	
.71-8	*Trifolium*	clover	a	seed	a	no	u	1	
.71-8	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.71-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	21	
.71-9	unknown botanical	unknown, ovoid	t	seed/achene	cf	yes	u	1	*Plantago?*
.71-9	unknown botanical	unknown, ovoid	t	seedcoat	cf	yes	u	1	
.71-9	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	6	
.71-9	*Polygonum*	knotweed-type	a	achene	a	yes	u	2	
.71-10	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	10	
.71-10	*Polygonum*	knotweed-type	t	achene	a	yes	u	1	
.71-10	*Lepidium densiflorum*-type	common peppergrass	cf	seed	a	no	u	2	
.71-10	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.71-11	*Polygonum*	knotweed-type	t	achene	a	yes	u	3	
.71-11	***Salvia hispanica***	**chia**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-11	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	17	
.71-11	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.71-11	***Papaver***	**poppy**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-11	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	6	
.71-11	***Melissa officinalis***	**lemonbalm**	**a**	**seed**	**a**	**no**	**c**	**3**	**new exotic**
.71-11	***Rosmarinus officinalis***	**rosemary**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-12	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	
.71-12	*Artemisia*-like	leaf	cf	leaf	cf	yes	u	1	
.71-12	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.71-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	15	
.71-13	*Polygonum*-like	knotweed-type	cf	seedcoat	a	yes	u	1	
.71-13	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.71-13	unknown botanical	unknown	t	bud	t	no	u	1	
.71-13	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.71-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.25-1	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	(4.75)
.25-1	unknown botanical	unknown	t	flowerhead	t	no	u	2	
.25-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(4.75)
.25-1	unknown botanical	unknown, ovoid, folded	t	seed	t	no	u	1	
.25-2	unknown botanical	unknown, ovoid, folded	t	seed	t	no	u	1	
.25-2	*Verbascum thapsus*	common mullein	a	seed	a	yes	u	1	new non exotic
.25-2	*Myosotis*	forget-me-not	a	seed	a	no	u	2	new non exotic
.25-2	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	(4.75)
.25-3	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	(4.75)
SAC stopping point (minimal volume)									
.25-4	unknown botanical	unknown, ovoid, folded	a	seed	a	no	u	1	
.25-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	3	
.25-4	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-4	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-4	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-4	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-5	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-5	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	2	
.25-6	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-6	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-6	unknown botanical	unknown, ovoid <.25	t	seed	t	no	u	2	
.25-6	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-7	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-7	unknown botanical	unknown	a	disseminule	cf	no	u	2	
.25-7	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-7	*Descurainia*	tansy mustard-type	t	seed	a	no	u	1	
.25-8	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-8	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
.25-8	*Artemisia*-type	sagebrush	t	flowerhead	cf	no	u	2	
.25-8	unknown botanical	unknown, ovoid, folded	t	seed	a	no	u	1	
.25-8	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-9	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-9	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-9	*Artemisia*-like	sagebrush-type	t	achene	t	no	u	1	
.25-9	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-9	unknown botanical	unknown, ovoid	t	seed	t	no	u	1	
.25-9	***Mentha***	**mint**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25-10	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-10	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-10	*Myosotis*	forget-me-not	a	seed	a	no	u	3	
.25-10	unknown botanical	unknown	t	disseminule	t	no	u	1	
.25-10	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-10	Poaceae	grass unknown	t	bracts	t	no	u	1	
.25-10	unknown botanical	unknown	t	seed	t	no	u	1	round, <.25 mm
.25-11	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-11	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-12	unknown botanical	unknown	t	disseminule	t	no	u	1	
.25-12	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-12	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-13	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-13	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-15	*Descurainia*	tansy mustard-type	t	seed	a	yes	u	1	
.25-15	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-15	unknown botanical	unknown	a	disseminule	t	no	u	1	
.25-16	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-16	unknown botanical	unknown, ovoid <.25 mm	t	seed	t	no	u	3	
.25-16	*Artemisia*-like	sagebrush	t	achene	t	no	u	2	
.25-16	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-16	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-16	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.25-17	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-17	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-17	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-17	unknown botanical	unknown, round	t	seedcoat	t	no	u	1	
.25-17	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-17	unknown botanical	unknown, ovoid	t	seedcoat	t	yes	u	1	
.25-18	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-18	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-19	unknown botanical	unknown, ovoid	t	seedcoat	t	yes	u	1	
.25-19	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-19	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-19	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-20	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
.25-20	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-20	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-20	unknown botanical	unknown, ovoid, ~.25	t	seedcoat	t	no	u	1	
.25-20	unknown botanical	unknown	t	flowerhead	t	no	u	1	
.25-21	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-21	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-21	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-21	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-22	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-22	unknown botanical	unknown,ovoid, <.25 mm	t	seed	t	no	u	2	
.25-22	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
.25-22	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-22	unknown botanical	unknown	t	seedcoat	t	yes	u	1	
.25-22	unknown botanical	unknown	t	flowerhead	t	no	u	1	
.25-23	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-23	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.25-24	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-25	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-25	*Silene*	catchfly/campion-type	a	seed	a	no	u	14	
.25-25	seed tissue type unknown	cf borage remains?	cf	tissue	cf	yes	c	1	
.25-26	*Silene*	catchfly/campion-type	a	seed	a	no	u	15	
.25-26	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-26	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-26	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-27	unknown botanical	unknown, round	t	seedcoat	t	no	u	1	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-27	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-27	*Silene*	catchfly/campion-type	a	seed	a	no	u	20	
.25-27	unknown botanical	unknown, round	t	seed	t	no	u	1	
.25-28	*Silene*	catchfly/campion-type	a	seed	a	no	u	18	
.25-28	*Descurainia*-type	tansy mustard-type	cf	seed	cf	no	u	1	
.25-28	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-28	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-29	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-29	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-29	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-30	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-30	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-30	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-31	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-31	*Descurainia*	tansy mustard	t	seed	a	no	u	1	
.25-31	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-31	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-31	*Descurainia*	tansy mustard	cf	seed	cf	no	u	1	
.25-31	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-32	*Silene*	catchfly/campion-type	a	seed	a	no	u	17	
.25-32	*Chenopodium /amaranthus*	cheno-am	a	seed	a	no	u	1	
.25-33	*Silene*	catchfly/campion-type	a	seed	a	no	u	16	
.25-33	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-34	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-34	*Artemisia*-like	seed/achene	cf	seed/achene	cf	no	u	1	
.25-34	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-34	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-35	*Silene*	catchfly/campion-type	a	seed	a	no	u	18	
.25-35	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-35	unknown botanical	unknown, ovoid, <.25 mm	t	seed	t	no	u	1	
.25-35	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-36	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-36	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	

continued…

Table A.3 Experiment 2, firepit 5 data: flotation sample 2 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-37	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-37	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-38	*Silene*	catchfly/campion-type	a	seed	a	no	u	20	
.25-38	*Myosotis*	forget-me-not	a	seed	a	no	u	4	
.25-38	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	2	
.25-38	*Verbascum thapsus*	common mullein	a	seed	a	yes	u	2	
.25-39	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-39	unkinown botanical	unknown, ovoid	t	seed	t	no	u	3	
.25-39	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-39	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-39	*Myosotis*	forget-me-not	a	seed	a	no	u	3	
.25-39	*Artemisia*-like	sagebrush-like	cf	flowerhead	t	no	u	1	
.25-39	*Chenopodium/amaranthus*	cheno-am	t	seed	t	no	u	1	
.25-40	*Silene*	catchfly/campion-type	a	seed	a	no	u	20	
.25-40	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-41	*Silene*	catchfly/campion-type	a	seed	a	no	u	23	
.25-41	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-41	unknown botanical	unknown, ovoid, <.25mm	t	seed	t	no	u	1	
.25-41	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-41	***Mentha***	**mint**	**a**	**seed**	**a**	**no**	**c**	**1**	**(.25-9)**
.25-42	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-42	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-42	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-43	black spherical body	black spherical body	cf	black spherical body	cf	no	c	2	
.25-43	*Silene*	catchfly/campion-type	a	seed	a	yes/no	u	7	
.25-43	unknown botanical	unknown, ovoid	t	seed	t	no	u	1	
.25-44	*Silene*	catchfly/campion-type	a	seed	a	yes/no	u	9	
.25-44	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-45	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-45	nonbotanical	live beetle	a	beetle	cf	no	u	1	

Notes
[a] "C" Analyst confidence: a (absolute); t (tentative); cf (compares favourably).
[b] "Frag" Fragment: yes/no.
[c] "Cond" Condition: c (charred); u (uncharred); pc (partially charred).
† specimens that would be unrecognized under normal conditions.

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery summary and 100 per cent survey results. Listed by light fraction screen size and order of recovery. All exotics identified in bold print. Species-area curve results shaded. All subsamples contain roots, twigs, insect parts and pellets (undocumented).

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
Exotic recovery summary									
2.8	***Cucurbita pepo***	**acorn squash**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Piper nigrum***	**black peppercorn**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Alcea***	**hollyhock**	**a**	**seed**	**a**	**no**	**c**	**1**	
2.8	***Secale cereale***	**fall rye**	**a**	**seed**	**a**	**no**	**c**	**3**	
1.4-1	***Lactuca sativa***	**lettuce**	**a**	**seed**	**a**	**no**	**c**	**1**	
Total unique exotics recovered								**7**	
Heavy fraction (quick scan)								**Nil**	
Individual screen recovery									
4.75 mm light fraction screen (no subsampling applied)									
4.75	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	2	
4.75	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	
4.75	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
4.75	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
4.75	*Myosotis*	forget-me-not	a	seed	a	no	u	3	
4.75	Poaceae	grass	t	spikelet/caryopsis	t	no	u	5	
4.75	unknown botanical	seedcoat frag	t	seedcoat	t	yes	u	1	
4.75	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	9	
4.75	unknown botanical	seed, ovoid	t	seed	a	no	u	1	
2.8 mm light fraction screen (no subsampling applied)									
2.8	***Cucurbita pepo***	**acorn squash**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Piper nigrum***	**black peppercorn**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Alcea***	**hollyhock**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Secale cereale***	**fall rye**	**a**	**seed**	**a**	**no**	**c**	**3**	**new exotic**
2.8	Poaceae	grass	t	spikelet/caryopsis	t	no	u	3	
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
1.4-1	***Lactuca sativa***	**lettuce**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-1	**Lithospermum arvense**	**corn gromwell**	**a**	**seedcoat half**	**a**	**no**	**u**	**1**	**(4.75)**
1.4-1	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	(4.75)
1.4-1	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-2	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	(4.75)
1.4-2	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	(4.75)
1.4-2	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	(4.75)
1.4-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(4.75)
1.4-3	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	(4.75)
1.4-4	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(4.75)
1.4-4	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)
1.4-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	(4.75)
SAC stopping point (minimal volume)									
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	
1.4-5	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
1.4-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-6	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
1.4-6	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-7	*Sinapis alba*	yellow mustard	a	seed	a	no	c	1	new exotic
1.4-7	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-7	*Polygonum*-type	Polygonum-type	cf	achene	cf	yes	u	2	
1.4-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	2	
1.4-7	*Silene*	catchfly/campion-type	a	bud & seed	a	no	u	2	
1.4-8	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-8	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-8	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	2	
1.4-9	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-9	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-10	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	
1.4-10	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-10	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	2	
1.4-10	*Polygonum*	knotweed-type	a	achene	a	no	u	2	

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-10	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
1.4-10	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
1.4-11	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
1.4-11	***Trigonella foenum-graecum***	**fenugreek**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-11	Poaceae	grass	a	spikelet/caryopsis	a	no	u	5	
1.4-11	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	
1.4-12	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	3	
1.4-12	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
1.4-12	***Sinapis alba***	**yellow mustard**	**a**	**seed**	**a**	**no**	**c**	**1**	**(1.4-7)**
1.4-12	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-12	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-12	*Polygonum*-type	Polygonum-type	cf	achene coat	cf	yes	u	2	
1.4-12	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-12	*Lithospermum arvense*	corn gromwell	a	whole seed	a	no	u	1	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-13	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-14	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-14	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-14	unknown botanical	unknown	a	bud	cf	no	u	1	
1.4-14	Poaceae	grass	a	caryopsis	a	no	u	1	
1.4-15	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
1.4-15	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-15	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-15	Poaceae	grass	a	caryopsis	a	no	u	1	
1.4-16	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	3	
1.4-16	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-16	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-16	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
1.4-16	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-16	***Chenopodium quinoa***	**quinoa**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-17	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-17	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-17	*Polygonum*	Polygonum-type	a	achene	a	yes	u	2	
1.4-17	*Lepidium densiflorum*-type	common peppergrass	cf	seed	a	no	u	1	

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	**Scientific name**	**Common name**	**C[a]**	**Part**	**C[a]**	**Frag[b]**	**Cond[c]**	**Count**	**Notes/found previously**
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-18	Poaceae	grass	a	caryopsis	a	no	u	1	
1.4-18	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-18	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
1.4-18	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-19	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-19	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	
1.4-19	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.71-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	14	(4.75)
.71-1	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
.71-2	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	(4.75)
.71-2	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	(4.75)
.71-2	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	(4.75)
.71-3	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	(4.75)
.71-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	10	(4.75)
.71-3	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	new non exotic
.71-3	*Myosotis*	forget-me-not	a	seed	a	no	u	3	(4.75)
SAC stopping point (minimal volume)									
.71-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	16	
.71-4	***Melissa officinalis***	**lemonbalm**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-4	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
.71-4	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.71-4	Poaceae	grass	t	spikelet/caryopsis	t	no	u	1	
.71-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	13	
.71-5	Poaceae	grass	t	spikelet/caryopsis	t	no	u	1	
.71-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	14	
.71-6	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
.71-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	13	
.71-7	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.71-7	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.71-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	16	
.71-8	*Polygonum*	knotweed-type	t	achene	t	yes	u	5	
.71-8	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	3	

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-8	***Physalis***	**common groundcherry**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-8	unknown botanical	seed, cuspidate	t	seed	t	no	u	1	white, folded
.71-8	***Portulaca***	**purslane**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	15	
.71-9	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
.71-9	*Polygonum*	knotweed-type	t	achene	t	yes	u	1	
.71-9	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
.71-10	***Papaver***	**poppy**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-10	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
.71-10	*Lithospermum arvense*	corn gromwell	a	seed frag	a	yes	u	1	
.71-10	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.71-10	*Lepidium densiflorum-type*	common peppergrass	a	pod half	a	yes	u	1	
.71-10	***Trifolium repens***	**clover**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-10	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.25-1	*Silene*	catchfly/campion-type	a	seed	a	no	u	14	(4.75)
.25-1	*Lepidium densiflorum*-type	common peppergrass	cf	seed	cf	no	u	1	(4.75)
.25-1	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	new non exotic
.25-1	*Centaurea* (*diffusa/maculosa*-type)	"sunflower" seed	cf	seed	cf	no	u	2	(4.75)
.25-2	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	(4.75)
.25-2	unknown botanical	seedcoat, unk	cf	seedcoat	cf	no	u	3	
.25-2	unknown botanical	tissue	t	tissue	t	yes	c	1	
.25-2	unknown botanical	flowerhead	t	flowerhead	t	no	u	1	
.25-2	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	(.25-1)
.25-2	*Sisymbrium*-type	tumblemustard	cf	seed	cf	no	u	1	new non exotic
.25-2	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	(4.75)
.25-3	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	(4.75)
.25-3	Poaceae	grass	t	spikelet/caryopsis	t	no	u	1	(4.75)
SAC stopping point (minimal volume)									
.25-4	*Silene*	catchfly/campion-type	a	seed	a	no	u	14	
.25-4	*Myosotis*	forget-me-not	t	seed	a	no	u	1	
.25-4	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-4	unknown botanical	unknown, round, <.25	t	seed	t	no	u	1	

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-4	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-4	unknown botanical	unknown, round	t	seedcoat	t	no	u	1	
.25-5	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-5	unknown unknown	black spherical body	cf	bsb	cf	no	c?	1	
.25-5	*Descurainia*-like	tansy mustard	t	seed	t	no	u	1	new non exotic
.25-5	*Verbascum thapsus*	common mullein	a	seed	a	yes	u	1	
.25-6	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-6	unknown botanical	unknown	cf	seedcoat	cf	no	u	1	flattened, central ridge
.25-7	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-7	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-7	unknown botanical	seedcoat, round	t	seedcoat	t	no	u	1	
.25-8	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-8	unknown botanical	unknown, round	t	seedcoat	t	no	u	2	<.25 mm in size
.25-9	unknown botanical	disseminule, unk	t	disseminule	t	no	u	1+	
.25-9	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-9	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-10	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-10	*Silene*	catchfly/campion-type	a	seed	a	no	u	21	
.25-10	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-11	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-11	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-11	*Myosotis*	forget-me-not	a	seed	a	no	u	3	
.25-11	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-12	*Silene*	bladder campion	a	seed	a	no	u	7	
.25-12	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-12	unknown botanical	unknown, ovate <.25	a	seed	a	no	u	1	
.25-13	***Nicotiana***	**tobacco**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-13	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-14	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-14	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	2	
.25-14	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-14	unknown botanical	unknown, round	cf	seed	a	no	u	1	*Brassica*-like

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-14	*Descurainia*-like	tansy mustard	a	seed	a	no	u	1	
.25-15	*Silene*	catchfly/campion-type	a	seed	a	no	u	25	
.25-15	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-15	nonbotanical	live beetle	a	beetle	a	no	u	1	
.25-16	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-16	unknown botanical	unknown	t	disseminule	t	no	u	1+	
.25-16	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-17	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-17	unknown botanical	unknown	cf	seedcoat	a	no	u	1	*Myosotis* (?)
.25-17	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-17	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-18	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-18	*Verbascum thapsus*	common mullein	a	seed	a	no	u	6	
.25-18	*Descurainia*-like	tansy mustard	cf	seed	cf	no	u	1	
.25-18	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-18	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-19	*Silene*	catchfly/campion-type	a	seed	a	no	u	19	
.25-19	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-19	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-19	*Descurainia*-like	tansy mustard	cf	seed	cf	no	u	1	
.25-20	Silene	catchfly/campion-type	a	seed	a	no	u	13	
.25-20	unknown botanical	unknown, ovoid	cf	seed	cf	no	u	3	
.25-20	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-20	unknown botanical	unknown	cf	seedcoat	cf	yes	u	1	
.25-20	unknown botanical	unknown, round	cf	seedcoat	cf	no	u	1	
.25-21	*Silene*	catchfly/campion-type	a	seed	a	no	u	18	
.25-21	unknown botanical	Polygonum-like	cf	seedcoat	cf	no	u	1	
.25-21	unknown botanical	unknown, elliptical	cf	seedcoat	cf	no	u	1	
.25-21	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-21	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-22	*Verbascum thapsus*	common mullein	a	seed	a	no	u	4	
.25-22	*Silene*	catchfly/campion-type	a	seed	a	no	u	28	
.25-22	unknown botanical	unknown	cf	seedcoat	cf	no	u	1	
.25-22	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-22	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	

continued…

Table A.4 Experiment 2, firepit 5 data: flotation sample 3 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-22	unknown botanical	unknown, ovoid	cf	seed	cf	no	u	1	
.25-22	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
.25-23	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-23	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-23	*Artemisia*-type	sagebrush-type	t	achene	cf	no	u	1	
.25-23	unknown botanical	unknown, round	cf	seed	cf	no	u	1	
.25-24	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-24	*Lepidium*-like	pepperweed	cf	seedcoat	cf	no	u	1	
.25-24	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-25	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-25	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-26	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-26	unknown botanical	unknown, elliptical	cf	seedcoat	cf	no	u	1	
.25-27	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-28	*Silene*	catchfly/campion-type	a	seed	a	no	u	21	
.25-28	unknown botanical	unknown, round	cf	seed	cf	no	u	1	

Notes
[a] "C" Analyst confidence: a (absolute); t (tentative); cf (compares favourably).
[b] "Frag" Fragment: yes/no.
[c] "Cond" Condition: c (charred); u (uncharred); pc (partially charred).
† speci mens that would be unrecognized under normal conditions.

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery summary and 100 per cent survey results. Listed by light fraction screen size and order of recovery. All exotics identified in bold print. Species-area curve results shaded. All subsamples contain roots, twigs, insect parts and pellets (undocumented).

Screen size/ subsample number	**Scientific name**	**Common name**	**C[a]**	**Part**	**C[a]**	**Frag[b]**	**Cond[c]**	**Count**	**Notes/found previously**
Exotic recovery summary									
4.75	***Cucurbita pepo***	**acorn squash**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Lagenaria siceraria***	**bottlegourd**	**a**	**seed**	**a**	**no**	**c**	**3**	**new exotic**
4.75	***Helianthus annuus***	**sunflower**	**a**	**achene**	**a**	**no**	**c**	**2**	**new exotic**
2.8	***Piper nigrum***	**black peppercorn**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Lathyrus latifolius***	**pea**	**a**	**seed**	**a**	**no**	**c**	**4**	**new exotic**
2.8	***Alcea***	**hollyhock**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Fagopyrum esculenteum***	**buckwheat**	**a**	**achene**	**a**	**no**	**c**	**1**	**new exotic**
1.4-1	***Chenopodium quinoa***	**quinoa**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
Total unique exotics recovered								**14**	
Individual screen recovery									
Heavy fraction (quick scan)								**Nil**	
4.75 mm light fraction screen (no subsampling applied)									
4.75	***Cucurbita pepo***	**acorn squash**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Lagenaria siceraria***	**bottlegourd**	**a**	**seed**	**a**	**no**	**c**	**3**	**new exotic**
4.75	***Helianthus annuus***	**sunflower**	**a**	**achene**	**a**	**no**	**c**	**2**	**new exotic**
4.75	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	new non exotic
2.8 mm light fraction screen (no subsampling applied)									
2.8	*Ipomoae*-like	morning glory-like	cf	seed	cf	no	u	2	new non exotic
2.8	Poaceae	grass	a	spikelet/caryopsis	t	no	u	5	
2.8	***Piper nigrum***	**black peppercorn**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Lathyrus latifolius***	**pea**	**a**	**seed**	**a**	**no**	**c**	**4**	**new exotic**
2.8	***Alcea***	**hollyhock**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
2.8	***Fagopyrum esculenteum***	**buckwheat**	**a**	**achene**	**a**	**no**	**c**	**1**	**new exotic**
2.8	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
1.4-1	*Chenopodium quinoa*	quinoa	a	seed	a	no	c	1	**new exotic**
1.4-1	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(2.8)
1.4-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	new non exotic
1.4-1	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	(2.8)

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-1	*Polygonum*	knotweed-type	a	achene	a	no	u	1	new non exotic
1.4-2	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(2.8)
1.4-2	Poaceae	grass	a	spikelet/caryopsis	a	no	u	4	(2.8)
1.4-2	*Polygonum*	knotweed-type	a	achene	a	yes	u	3	(1.4-1)
1.4-2	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	new non exotic
1.4-3	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(2.8)
1.4-4	*Lepidium densiflorum*-type	common peppergrass	a	whole pod	a	no	u	1	(2.8)
1.4-4	unknown botanical	unknown	a	bud/capsule	t	no	u	1	
1.4-4	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(2.8)
1.4-4	*Polygonum*	knotweed-type	a	achene	a	no	u	1	(1.4-1)
1.4-4	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	(1.4-1)
SAC stopping point (minimal volume)									
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	intact pod	a	no	u	1	
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	3	
1.4-5	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-5	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-5	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
1.4-5	unknown botanical	unknown	a	bud/capsule	t	yes	u	1	
1.4-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-6	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	5	
1.4-6	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-7	Poaceae	grass	a	spikelet/caryopsis	a	no	u	5	
1.4-7	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	3	
1.4-7	*Polygonum*-type	Polygonum unknown	a	achene	a	no	u	1	
1.4-7	unknown botanical	unknown	a	bud/capsule	t	no	u	2	
1.4-8	***Trigonella foenum-graecum***	**fenugreek**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-8	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-8	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-8	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-9	Poaceae	grass	a	spikelet/caryopsis	a	no	u	7	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-9	*Lithospermum arvense*	corn gromwell	a	seed	a	no	u	1	
1.4-9	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-10	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	pod and seed	a	no	u	1	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-10	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-11	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-11	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-11	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-11	*Lithospermum arvense*	corn gromwell	a	seed	cf	yes	u	1	
1.4-12	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	4	
1.4-12	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	
1.4-12	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-12	Poaceae	grass	a	spikelet/caryopsis	a	no	u	5	
1.4-13	*Trigonella foenum-graecum*	fenugreek	a	seed	a	no	c	1	(1.4-8 mm)
1.4-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-13	unknown botanical	unknown	a	bud/capsule	t	no	u	1	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-13	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
1.4-13	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
1.4-14	Poaceae	grass	a	spikelet/caryopsis	a	no	u	5	
1.4-14	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-14	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-14	*Lepidium densiflorum*-type	common peppergrass	a	pod half and seed	a	no	u	1	
1.4-14	Centaurea (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.71-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	seed	t	no	u	15	(1.4-1)
.71-1	*Polygonum*	knotweed-type	t	achene	t	no	u	1	(1.4-1)
.71-1	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	(2.8)

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.71-1	unknown botanical	unknown	cf	bud	cf	no	u	1	
.71-1	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	yes	u	1	(1.4-2)
.71-2	*Polygonum*	knotweed-type	t	achene	a	no	u	2	(1.40-1)
.71-2	*Lepidium densiflorum*-type	common peppergrass	a	pod & seed	a	no	u	1	(2.8)
.71-2	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	(1.4-1)
.71-2	unknown	Polygonum-like	t	seedcoat	cf	yes	u	1	
.71-2	Poaceae	grass	cf	spikelet/caryopsis	t	yes	u	1	(2.8)
.71-2	*Polygonum*-type	smartweed-type	cf	achene	t	yes	u	1	(1.4-1)
.71-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	6	(1.4-1)
.71-3	*Lepidium densiflorum*-type	common peppergrass	t	seedcoat	a	no	u	1	(2.8)
.71-3	*Polygonum*	knotweed-type	t	achene	a	no	u	1	(1.4-1)
SAC stopping point (minimal volume)									
.71-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
.71-4	*Polygonum*	knotweed-type	t	achene	t	no	u	2	
.71-4	*Polygonum*	knotweed-type	t	achene	t	yes	u	1	
.71-4	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	1	
.71-4	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	yes	u	1	
.71-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	14	
.71-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	2	
.71-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
.71-6	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-6	*polgyonum*	knotweed-type	t	achene	t	no	u	1	
.71-6	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	1	
.71-6	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.71-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	10	
.71-7	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	2	
.71-7	Poaceae	grass	t	spikelet/caryopsis	t	no	u	2	
.71-7	*Polygonum*	knotweed-type	t	achene	t	yes	u	2	
.71-7	unknown botanical	unknown	t	disseminule	t	no	u	3	
.71-7	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.71-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	11	
.71-8	**Rosmarinus officinalis**	**rosemary**	**a**	**seed**	**a**	**no**	**c**	**2**	**new exotic**
.71-8	**Ocimum basilicum**	**basil**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-8	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	2	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-8	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	2	
.71-8	*Polygonum*	knotweed-type	t	achene	t	yes	u	2	
.71-8	***Salvia hispanica***	**chia**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-8	*Polygonum*	knotweed-type	t	achene	t	no	u	2	
.71-9	*Polygonum*	knotweed-type	t	achene	t	yes	u	7	
.71-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	21	
.71-9	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	2	
.71-9	*Trifolium*-type	clover	t	seed	a	no	u	1	
.71-9	unknown botanical	unknown	t	disseminule	cf	no	u	1	
.71-9	*Lepidium densiflorum*-type	common peppergrass	cf	seed	cf	no	u	1	
.71-9	*Lepidium densiflorum*-type	ballmustard	a	seed	a	no	u	1	
.71-9	***Apium graveolens***	**celery**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-10	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	11	
.71-10	unknown botanical	unknown	t	disseminule	cf	no	u	1	
.71-10	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	1	
.71-10	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	2	
.71-10	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.71-10	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	1	
.71-11	***Trifolium repens***	**clover**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-11	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	17	
.71-11	*Chenopodium/amaranthus*	cheno-am	t	seed	t	no	u	2	
.71-11	***Physalis***	**common groundcherry**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-11	***Lactuca sativa***	**lettuce**	**a**	**seed**	**a**	**no**	**c**	**2**	**new exotic**
.71-11	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	2	
.71-11	*Polygonum*	knotweed-type	t	achene	a	yes	u	6	
.71-11	Poaceae	grass	t	spikelet/caryopsis	t	no	u	1	
.71-11	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	1	
.71-11	*Lepidium densiflorum*-type	common peppergrass	t	pod half	a	no	u	1	
.71-12	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-12	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.71-12	*Lepidium densiflorum*-type	common peppergrass	cf	seed	cf	no	u	1	
.71-12	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	9	
.71-12	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
.71-12	*Polygonum*	knotweed-type	t	achene	t	yes	u	1	
.71-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-13	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.71-13	unknown botanical	unknown	t	disseminule	t	no	u	2	
.71-13	*Polygonum*	knotweed-type	t	achene	t	yes	u	1	
.71-14	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	6	
.71-14	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.71-14	*Polygonum*	knotweed-type	t	achene	a	no	u	2	
.71-14	*Lepidium densiflorum*-type	common peppergrass	t	seed	cf	no	u	2	
.71-15	*Polygonum*	knotweed-type	t	achene	t	yes	u	1	
.71-15	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.71-15	Poaceae	grass	t	spikelet/caryopsis	t	no	u	1	
.71-15	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	14	
.71-15	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.71-16	*Lithospermum arvense*	corn gromwell	a	seedhalf	a	no	u	1	
.71-16	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	
.71-16	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.71-16	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.25-1	unknown botanical	unknown	t	tissue	t	yes	c	1+	
.25-2	unknown botanical	unknown ovoid	t	seedcoat	t	no	u	1	
.25-3	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	new non exotic
.25-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	(1.4-1)
SAC stopping point (minimal volume)									
.25-4	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-4	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-5	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-6	unknown botanical	unknown	cf	disseminule	cf	no	u	2	
.25-6	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-7	unknown botanical	unknown ovoid	t	seed	t	no	u	1	
.25-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-7	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-8	unknown botanical	unknown ovoid	t	seed	t	no	u	1	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-8	unknown botanical	unknown	t	flowerhead	t	no	u	1	
.25-9	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-9	unknown botanical	unknown	t	disseminule	t	no	u	2	
.25-9	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-10	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-11	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-12	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-12	***Lobelia***	**Lobelia**	**cf**	**seed**	**cf**	**no**	**c**	**1**	**new exotic (specimen lost)**
.25-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-13	unknown botanical	unknown round	t	seedcoat	t	no	u	2	
.25-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-14	***Erogrostis teff***	**teff**	**t**	**seed**	**t**	**yes**	**c**	**1**	**new exotic**
.25-14	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-15	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-16	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-16	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-16	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-17	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-18	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-19	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-19	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-19	unknown	black spherical body	cf	black spherical body	cf	no	u?	3	
.25-20	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-20	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-21	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-21	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-21	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-21	unknown botanical	unknown ovoid	t	seed	t	no	u	1	
.25-21	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-22	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-22	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-22	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-23	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-23	*Myosotis*	forget-me-not	a	seed	a	no	u	1	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-24	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-24	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
.25-25	unknown botanical	unknown ovoid	t	seed	t	no	u	1	<.25 mm
.25-25	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-26	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-26	unknown botanical	unknown round	cf	seed?	?	no	u	1	
.25-27	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-27	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-28	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-28	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-29	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-29	unknown	unknown wrinkled	t	seed	t	no	u	1	
.25-30	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-31	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-31	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-32	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-33	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-34	unknown botanical	unknown ovate	t	seedcoat	t	no	u	1	
.25-34	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-35	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-35	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-35	*Myosotis*	forget-me-not	a	seedcoat	a	no	u	1	
.25-35	unknown botanical	unknown ovate	t	seed	t	no	u	1	
.25-36	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-36	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-36	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-37	-								
.25-38	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-38	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-39	unknown botanical	unknown ovoid	t	seed	t	no	u	1	
.25-39	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-39	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-40	*Verbascum thapsus*	common mullein	a	seed	a	yes	u	1	
.25-40	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-41	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-41	unknown botanical	unknown ovate	t	seedcoat	t	no	u	1	
.25-41	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-41	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-42	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-43	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-43	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-43	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-43	unknown	black spherical body	cf	blk sph body	cf	no	u	1	
.25-44	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-44	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-44	unknown botanical	unknown ovate	cf	seed	cf	no	u	1	similar to *Myositis*
.25-44	unknown botanical	unknown ovoid	cf	seed	cf	no	u	1	
.25-45	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-45	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-45	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-46	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-46	unknown botanical	unknown round	t	seedcoat	t	no	u	1	
.25-47	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-47	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-48	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-48	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	2	
.25-49	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-50	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-50	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-50	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-50	unknown botanical	unknown ovoid	t	seedcoat	cf	no	u	2	
.25-51	unknown botanical	unknown ovoid	t	seedcoat	cf	no	u	1	
.25-51	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-51	unknown botanical	unknown	t	flowerhead	t	no	u	1	
.25-51	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
.25-51	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-51	unknown botanical	unknown ovate	t	seed	t	no	u	1	
.25-51	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-52	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-52	unknown botanical	unknown ovoid	t	seed	t	no	u	2	
.25-52	unknown botanical	unknown	t	disseminule	t	no	u	2	
.25-53	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-53	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-53	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-54	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-54	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-55	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-55	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-55	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-56	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-56	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-56	unknown botanical	unknown ovoid	t	seed	t	no	u	1	
.25-57	*Medicago lupulina*	black medick	cf	seed	t	no	u	2	new non exotic
.25-57	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-57	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-58	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-58	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-58	unknown botanical	unknown ovate	cf	seed	cf	no	u	1	<.25 mm
.25-58	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-59	unknown botanical	unknown ovate	cf	seed	cf	no	u	1	<.25 mm
.25-59	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-59	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-60	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-60	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-60	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	t	yes	u	1	
.25-61	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-61	unknown	white spherical body	cf	white spherical body	cf	no	u	1	
.25-61	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-62	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-62	unknown botanical	unknown round	t	seed	t	no	u	2	
.25-63	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-63	unknown botanical	unknown round	t	seedcoat	cf	no	u	1	<.25 mm
.25-64	Silene	catchfly/campion-type	a	seed	a	no	u	5	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-64	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-65	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-65	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-66	*Silene*	catchfly/campion-type	a	seed	a	no	u	14	
.25-66	unknown botanical	unknown	t	disseminule	t	no	u	1	
.25-66	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-67	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-67	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-68	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-68	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-68	unknown botanical	unknown	t	disseminule	t	no	u	1	
.25-69	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-69	unknown botanical	unknown ovate	t	seedcoat	t	no	u	1	
.25-69	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-69	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-70	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-71	*Descurainia*	tansy mustard	cf	seed	cf	no	u	1	
.25-71	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-72	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-72	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-72	*Medicago lupulina*	black medick-like	cf	seed	cf	no	u	1	
.25-72	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-73	unknown	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-73	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-73	unknown botanical	unknown ovate	t	seed	t	no	u	1	
.25-74	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-74	*Myosotis*	forget-me-not	a	seed	a	yes	u	1	
.25-75	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-75	unknown botanical	unknown ovoid	t	seed	t	no	u	2	
.25-75	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-75	unknown	white spherical body	cf	white spherical body	cf	no	u	1	
.25-75	unknown botanical	unknown	t	disseminule	cf	no	u	1	
.25-76	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-76	non-botanical	live beetle						1	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-76	non-botanical	live beetle						1	
.25-76	unknown botanical	unknown	cf	disseminule	cf	no	u	2	
.25-76	*Lepidium*-like	peppergrass-type	cf	seedcoat	t	no	u	1	
.25-77	non-botanical	live beetle						1	
.25-77	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-78	unknown botanical	unknown ovate	t	seedcoat	t	no	u	1	
.25-78	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-78	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-78	unknown botanical	unknown	t	seedcoat	cf	no	u	2	
.25-78	unknown botanical	unknown ovate	t	seed	t	no	u	1	
.25-79	unknown botanical	unknown	t	seedcoat	t	yes	u	1	
.25-79	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-79	unknown botanical	unknown	cf	flowerhead	cf	no	u	1	(*Artemisia* (cf)
.25-79	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-80	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-80	unknown botanical	unknown	t	seedcoat	t	yes	u	1	
.25-80	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-81	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-81	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-81	unknown botanical	unknown	t	flowerhead	cf	no	u	2	*Artemisia* (cf)
.25-82	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-82	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-82	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-82	unknown botanical	unknown	t	seedcoat	cf	no	u	1	
									Myosotis (cf)
.25-83	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-83	*Descurainia*	tansy mustard	a	seed	a	no	u	1	
.25-83	unknown botanical	unknow ovate	t	seedcoat	cf	no	u	1	
.25-84	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-84	unknown botanical	unknown ovate	t	seedcoat	cf	no	u	1	
.25-85	*Myosotis*	forget-me-not	a	seedcoat	a	no	u	1	
.25-85	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-85	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-85	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	**Scientific name**	**Common name**	**C[a]**	**Part**	**C[a]**	**Frag[b]**	**Cond[c]**	**Count**	**Notes/found previously**
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-86	*Verbascum thapsus*	common mullein	a	seedcoat	a	yes	u	1	
.25-86	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-86	unknown botanical	unknown	t	flowerhead	cf	no	u	1	*Artemisia* (cf)
.25-87	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-87	*Verbascum thapsus*	common mullein	a	seedcoat	a	yes	u	1	
.25-88	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-89	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-89	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-90	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-90	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-91	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-91	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-91	*Descurainia*	tansy mustard	cf	seed	cf	no	u	1	
.25-91	*Medicago lupulina*	black medick	cf	seed cluster	cf	no	u	1	2 seeds in a cluster
.25-91	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-91	unknown botanical	unknown	t	seed?	t	no	u	1	*Artemisia?*
.25-92	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-92	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-92	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-93	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-93	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-94	unknown botanical	unknown round	t	seed	cf	no	u	1	
.25-94	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-94	***Lobelia***	**Lobelia**	**cf**	**seed**	**cf**	**no**	**c**	**1**	**(.25-12 mm)**
.25-94	unknown botanical	unknown	t	flowerhead	t	no	u	1	
.25-94	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-94	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
.25-94	unknown botanical	cheno-am-like	t	seedcoat	cf	yes	u	1	
.25-95	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-95	unknown botanical	unknown round	t	seed	t	no	u	1	cheno-am (cf)
.25-96	*Silene*	catchfly/campion-type	t	seed	a	no	u	4	
.25-96	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-96	*Myosotis*	forget-me-not	a	seed	a	no	u	1	

continued…

Table A.5 Experiment 2, firepit 5 data: flotation sample 4 exotic recovery, continued.

Screen size/ subsample number	**Scientific name**	**Common name**	**C[a]**	**Part**	**C[a]**	**Frag[b]**	**Cond[c]**	**Count**	**Notes/found previously**
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-97	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-97	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-97	unknown botanical	black spherical body	cf	black spherical body	cf	no	u?	1	
.25-98	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-98	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-98	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-98	unknown botanical	unknown ovoid	t	seedcoat	t	yes	u	1	
.25-98	unknown botanical	unknown	t	disseminule	t	no	u	1	

Notes
[a] "C" Analyst confidence: a (absolute); t (tentative); cf (compares favourably).
[b] "Frag" Fragment: yes/no.
[c] "Cond" Condition: c (charred); u (uncharred); pc (partially charred).
† specimens that would be unrecognized under normal conditions.

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary and 100 per cent survey results. Listed by light fraction screen size and order of recovery. All exotics identified in bold print. Species-area curve results shaded. All subsamples contain roots, twigs, insect parts and pellets (undocumented).

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
Exotic recovery summary									
4.75 mm	*Cucurbita pepo*	acorn squash	a	seed	a	no	c	1	
4.75 mm	*Piper nigrum*	black pepper	a	fruit	a	no	c	1	
4.75 mm	*Lagenaria siceraria*	bottlegourd	a	seed	a	no	c	1	
4.75 mm	*Tropaeolum*	nasturtium	a	seed	a	no	c	2	
4.75 mm	*Phaseolus vulgaris*	bean	a	cotyledon	a	no	c	1	
4.75 mm	*Zea mays*	corn	a	caryopsis	a	no	pc	2	
2.8 mm	*Fagopyrum*	buckwheat	a	achene	a	no	c	1	
.25-2	*Nicotiana*	tobacco	a	seed	a	no	c	1	
Total unique exotics recovered								10	
Individual screen recovery									
Heavy fraction (quick scan)									
surface	***Zea mays***	**corn**	**a**	**caryopsis**	**a**	**no**	**c**	**1**	not included in count†
4.75 mm light fraction screen (no subsampling applied)									
4.75	***Cucurbita pepo***	**acorn squash**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Piper nigrum***	**black pepper**	**a**	**fruit**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Lagenaria siceraria***	**bottlegourd**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Tropaeolum***	**nasturtium**	**a**	**seed**	**a**	**no**	**c**	**2**	**new exotic**
4.75	***Phaseolus vulgaris***	**bean**	**a**	**cotyledon**	**a**	**no**	**c**	**1**	**new exotic**
4.75	***Zea mays***	**corn**	**a**	**caryopsis**	**a**	**no**	**pc**	**2**	**new exotic**
4.75	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
4.75	rodent	unknown	cf	fecal pellet	cf	no	u	1	
4.75	*Lepidium densiflorum*-type	common peppergrass	a	pod	a	no	u	1.5	
4.75	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
4.75	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	
4.75	unknown botanical	unknown	a	seed/nutshell	t	yes	u	1	
2.8 mm light fraction screen (no subsampling applied)									
2.8	**Fagopyrum**	**buckwheat**	**a**	**achene**	**a**	**no**	**c**	**1**	**new exotic**

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
1.4-1	**Lithospermum arvense**	**corn gromwell**	**a**	**seed**	**a**	**yes**	**u**	**1**	**new non exotic**
1.4-1	*Polygonum*	knotweed-type	a	achene	a	no	u	1	new non exotic
1.4-1	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(4.75)
1.4-1	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	(4.75)
1.4-1	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	(1.4-1)
1.4-2	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	(4.75)
1.4-2	*Polygonum*	knotweed-type	a	achene	a	no	u	1	(1.4-1)
1.4-2	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	(4.75)
1.4-3	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	(4.75)
1.4-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	(4.75)
1.4-3	unknown botanical	unknown	a	bud	t	yes	u	1	
1.4-3	*Polygonum*	knotweed-type	a	achene	a	no	u	3	(1.4-1)
1.4-3	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	5	(4.75)
1.4-3	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	(4.75)
1.4-3	*Polygonum*	knotweed-type	a	achene	a	yes	u	1	(1.4-1)
1.4-3	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	(1.4-1)
1.4-3	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	(4.75)
SAC stopping point (minimal volume)									
1.4-4	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-4	Poaceae	grass	a	spikelet/caryopsis	a	yes	u	1	
1.4-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-4	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-4	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	2	
1.4-4	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	
1.4-4	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-5	Poaceae	grass	a	spikelet/caryopsis	a	no	u	6	
1.4-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	
1.4-5	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-5	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-5	***Erogrostis tef***	**teff**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-6	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	
1.4-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-6	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-6	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
1.4-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-7	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	2	
1.4-7	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-8	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-8	*Polygonum*	unknown type	a	achene	a	yes	u	1	
1.4-8	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-8	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-8	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
1.4-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	1	
1.4-9	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-9	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-10	Poaceae	grass	a	spikelet/caryopsis	a	no	u	4	
1.4-10	unknown botanical	unknown	a	seedcoat	cf	yes	u	1	
1.4-10	*Lithospermum arvense*	corn gromwell	a	whole seed	a	no	u	1	
1.4-10	*Lepidium*-like	common peppergrass-like	t	pod half	cf	yes	u	1	
1.4-11	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-11	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-11	Lepidium *densiflorum*-type	common peppergrass	a	pod half & seed	a	no	u	1	
1.4-11	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	3	
1.4-11	unknown botanical	unknown	a	bud/capsule	t	no	u	1	
1.4-11	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
1.4-12	Poaceae	grass	a	spikelet/caryopsis	a	no	u	7	
1.4-12	*Polygonum*	knotweed-type	a	achene	a	yes	u	2	
1.4-12	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	
1.4-12	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
1.4-12	*Lepidium densiflorum*-type	common peppergrass	a	pod half & seed	a	no	u	1	
1.4-12	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	yes	u	1	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	2	
1.4-13	unknown botanical	unknown	a	capsule	t	no	u	1	
1.4-13	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
1.4 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
1.4-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	1	
1.4-14	*Polygonum*	knotweed-type	a	achene	a	no	u	3	
1.4-14	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
1.4-14	Poaceae	grass	a	spikelet/caryopsis	a	no	u	2	
1.4-14	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-15	Poaceae	grass	a	spikelet/caryopsis	a	no	u	3	
1.4-15	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
1.4-15	Poaceae	grass	a	caryopsis	a	no	u	1	
1.4-15	*Lepidium densiflorum*-type	common peppergrass	a	seed	a	no	u	2	
1.4-15	*Lepidium densiflorum*-type	common peppergrass	a	pod	a	no	u	1	
1.4-15	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
1.4-15	***Chenopodium quinoa***	**quinoa**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
1.4-15	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-16	*Lepidium densiflorum*-type	common peppergrass	a	pod half	a	no	u	1	
1.4-16	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.71-1	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	(4.75)
.71-2	*Lithospermum arvense*	corn gromwell	a	achene half	a	no	u	1	(1.4-1)
.71-2	*Polygonum*	knotweed-type	a	achene	a	no	u	1	(1.4-1)
.71-2	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(4.75)
.71-2	Poaceae	grass	a	spikelet/caryopsis	a	no	u	1	(4.75)
.71-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	15	(4.75)
.71-3	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	2	(1.4-1)
.71-3	*Polygonum*	knotweed-type	a	achene	a	no	u	3	(1.4-1)
.71-3	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	3	new non exotic
.71-3	*Trifolium*	clover	cf	seedcoat	cf	no	u	1	new non exotic
SAC stopping point (minimal volume)									
.71-4	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
.71-4	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.71-5	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	2	
.71-5	**Borago**	**borage**	**cf**	**seed**	**a**	**yes**	**u**	**1**	**new exotic**
.71-5	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
.71-6	**Borago**	**borage**	**cf**	**seed**	**a**	**yes**	**u**	**1**	**(.71-5 mm)**
.71-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-6	*Polygonum*	knotweed-type	a	achene	a	no	u	2	
.71-6	***Papaver***	**poppy**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	
.71-7	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	3	
.71-7	***Ocimum basilicum***	**basil**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-7	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.71-8	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.71-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	13	
.71-8	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.71-8	*Polygonum*	knotweed-type	a	achene	a	no	u	1	
.71-9	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	3	
.71-9	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	5	
.71-9	unknown botanical	unknown, ovate	cf	seed	a	yes	u	1	
.71-10	***Apium graveolens***	**celery**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-10	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	10	
.71-10	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.710-10	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.71-10	*Sisymbrium*-type	tall tumblemustard-like	t	seed	a	no	u	1	new non exotic
.71-11	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	t	no	u	1	
.71-11	*Polygonum*	knotweed-type	t	achene	t	no	u	2	
.71-11	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	3	
.71-11	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	15	
.71-12	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no		18	
.71-12	*Polygonum*	knotweed-type	t	achene	t	no	u	2	
.71-12	***Salvia hispanica***	**chia**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-12	unknown botanical	unknown	t	tissue	t	yes	u	1	
.71-13	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	3	
.71-13	*Lithospermum arvense*	corn gromwell	a	?	a		u	1	
.71-13	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-13	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	
.71-14	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	16	
.71-14	*Lithospermum arvense*	corn gromwell	a	seedcoat	a	yes	u	1	
.71-14	*Sisymbrium*-type	tumblemustard-type	t	seed	t	no	u	1	
.71-14	*Lepidium densiflorum*-type	common peppergrass	a	pod	a	no	u	1	
.71-14	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.71 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.71-15	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	9	
.71-15	*Chenopodium/amaranthus*	cheno-am	a	seedcoat	a	no	u	2	
.71-15	*Lithospermum arvense*	corn gromwell	a	seed	a	yes	u	2	
.71-15	***Borago***	**borage**	**a**	**seed**	**a**	**yes**	**u**	**2**	**(.71-5)**
.71-15	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.71-15	*Polygonum*	smartweed-type	a	achene	a	yes	u	1	
.71-15	*Polygonum*	knotweed-type	a	achene	a	no	u	5	
.71-15	***Borago***	**borage**	**cf**	**tubercle**	**cf**	**yes**	**c**	**1**	**(.71-5)**
.71-16	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	
.71-16	*Sisymbrium*-type	tumblemustard-type	t	seedcoat	u	yes	u	1	
.71-17	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	
.71-17	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-17	*Borago*	borage	cf	tissue	cf	yes	c	1	
.71-18	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	10	
.71-18	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	t	achene	cf	no	u	1	
.71-18	*Polygonum*	knotweed-type	t	achene	a	no	u	1	
.71-18	***Borago***	**borage**	**cf**	**tubercle**	**cf**	**yes**	**c**	**1**	**(.71-5)**
.71-19	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	10	
.71-19	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.71-19	***Trifolium***	**clover**	**cf**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.71-19	*Lithospermum arvense*	corn gromwell	a	seedcoat half	a	no	u	1	
.71-20	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	7	
.71-21	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	12	
.71-21	*Polygonum*	smartweed-type	t	achene	a	yes	u	1	
.71-21	***Papaver***	**poppy**	**a**	**seed**	**a**		**c**	**1**	**(.71-6)**
.71-22	***Papaver***	**poppy**	**a**	**seed**	**a**		**c**	**1**	**(.71-7)**
.71-22	***Borago***	**borage**	**cf**	**tubercle**	**cf**	**yes**	**c**	**1**	**(.71-5)**
.71-22	*Polygonum*	knotweed-type	t	achene	a	no	u	3	
.71-22	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	1	
.71-22	*Sisymbrium*-type	tumblemustard-type	t	seed	a	no	u	3	
.71-22	*Lithospermum arvense*	corn gromwell	a	seed	a	no	u	1	
.71-22	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	8	
.71-23	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	?	1	
.71-23	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	4	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable)									
.25-1	*Lepidium densiflorum*-type	common pepperweed	t	seed	a	no	u	1	(4.75)
.25-1	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	(4.75)
.25-2	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	(4.75)
.25-2	***Nicotiana***	**tobacco**	**a**	**seed**	**a**	**no**	**c**	**1**	**new exotic**
.25-2	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	(.71-3)
.25-2	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	new non exotic
.25-3	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	(4.75)
.25-3	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	(.25-2)
.25-3	*Borago*-type	borage	cf	tissue	cf	yes	c	1	
.25-3	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	(4.75)
.25-3	*Polygonum*	knotweed-type	t	achene	a	no	u	1	(1.4-1)
.25-3	*Artemisia absinthian*	absinthian	cf	achene	cf	no	u	1	new non exotic
.25-4	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	(4.75)
.25-4	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	(.25-2)
.25-5	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	(4.75)
.25-5	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	(.25-2)
.25-5	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	1	(.71-3)
SAC stopping point (minimal volume)									
.25-6	*Verbascum thapsus*	common mullein	a	seed	a	no	u	3	
.25-6	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-6	*Myosotis*	forget-me-not	a	seed	a	no	u	2	new non exotic
.25-6	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-7	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	2	
.25-7	*Silene*	catchfly/campion-type	a	seed	a		u	6	
.25-7	*Artemisia absinthium*	absinthium	cf	achene	cf	no	u	1	(.25-3)
.25-7	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.25-8	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-8	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-8	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	3	
.25-8	***Portulaca***	**purslane**	**a**	**seed**	**a**	**no**	**c**	**2**	**new exotic**
.25-8	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	1	
.25-9	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-9	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-9	***Erogrostis tef***	**teff**	**a**	**seed**	**a**	**no**	**c**	**1**	**(1.4-5)**

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-10	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-10	***Nicotiana***	**tobacco**	**cf**	**seed**	**a**	**no**	**c**	**1**	**(.25-2)**
.25-10	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-10	***Erogrostis tef***	**teff**	**a**	**seed**	**a**	**no**	**c**	**1**	**(1.4-5)**
.25-10	unknown nonbotanical	bone	t	bone	t	yes	u	1	
.25-11	*Silene*	catchfly/campion-type	a	seed	a	no	u	17	
.25-11	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-12	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-12	Poaceae	grass	t	spikelet/caryopsis	t	no	u	1	
.25-12	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	1	
.25-12	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-13	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-13	*Artemisia absinthium*	absinthium	cf	achene	cf	no	u	1	
.25-13	unknown botanical	unknown, ovoid	t	seed	cf	no	u	1	
.25-13	*Myosotis*	forget-me-not	cf	seed	a	no	u	1	(.25-6)
.25-14	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	2	
.25-14	*Polygonum*	knotweed-type	t	achene	a	yes	u	1	
.25-14	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-14	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-14	*Descurainia*-type	tansy mustard-type	t	seed	a	no	u	1	new non exotic
.25-14	*Myosotis*	forget-me-not	cf	seed	a	no	u	1	
.25-14	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-15	unknown botanical	unknown	cf	flowerhead	cf	no	u	1	
.25-15	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-15	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	yes	u	3	
.25-16	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-16	***Erogrostis tef***	**teff**	**a**	**seed**	**a**	**no**	**c**	**1**	**(1.4-5)**
.25-16	*Brassica*-type	unknown mustard-type	a	seed	a	no	u	1	not unlike *Lepidium*
.25-16	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-17	*Chenopodium/amaranthus*	cheno-am	a	seed	a	no	u	2	
.25-17	*Silene*	catchfly/campion-type	a	seed	a	no	u	1	
.25-17	*Descurainia*-type	tansy mustard-type	cf	seed	cf	no	u	1	(.25-14)
.25-17	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-18	*Myosotis*	forget-me-not	cf	seed	cf	no	u	1	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-18	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-18	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-18	*Chenopodium/amaranthus*	cheno-am	cf	seedcoat	cf	no	u	1	
.25-19	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-19	*Descurainia*-type	tansy mustard-type	cf	seed	cf	no	u	3	
.25-19	*Chenopodium/amaranthus*	cheno-am	cf	seedcoat	cf	no	u	1	
.25-20	unknown botanical	unknown, round	cf	seed	cf	no	u/c?	1	
.25-20	*Silene*	catchfly/campion-type	a	seed	a	no	u	16	
.25-20	*Lepidium densiflorum*-type	common peppergrass	cf	seed	a	no	u	1	
.25-20	*Descurainia*-type	tansy mustard-type	cf	seed	a	no	u	1	
.25-21	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-21	*Myosotis*	forget-me-not	cf	seed	a	no	u	1	
.25-21	*Descurainia*-type	tansy mustard-type	cf	seed	cf	no	u	1	
.25-21	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-22	*Lepidium densiflorum*-type	common peppergrass	t	seed	a	no	u	1	
.25-22	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-22	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-22	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-23	unknown nonbotanical	bone	t	bone	cf	yes	u	1	
.25-23	unknown botanical	unknown	t	bud	t	no	u	1	
.25-23	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-23	unknown botanical	disseminule	t	disseminule	t	no	u	1	
.25-23	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-24	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	cf	no	u	1	
.25-24	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-24	unknown nonbotanical	live beetle	cf	live beetle	cf	no	u	1	
.25-24	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-25	*Silene*	catchfly/campion-type	a	seed	a	no	u	16	
.25-25	*Verbascum thapsus*	common mullein	a	seed	a	no	u	4	
.25-25	*Polygonum*	knotweed-type	t	achene	t	no	u	1	
.25-26	*Silene*	catchfly/campion-type	a	seed	a	no	u	16	
.25-27	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-27	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-27	***Origanum vulgare***	**oregano**	**a**	**seed**	**a**		**c**	**1**	**new exotic**
.25-27	unknown botanical	unknown, ovoid	cf	seed	cf	no	u	1	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-28	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-28	*Silene*	catchfly/campion-type	a	seed	a	no	u	11	
.25-28	***Nicotiana***	**tobacco**	**t**	**seed**	**a**	**no**	**c**	**2**	**(.25-2)**
.25-28	unknown botanical	unknown, Silene-like	t	seed	t	no	c	1	
.25-29	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-29	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-30	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-30	*Silene*	catchfly/campion-type	a	seed	a	no	u	17	
.25-30	unknown botanical	unknown	cf	disseminule	cf	no	u	1	
.25-30	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-31	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-32	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-32	*Lepidium*-type	pepperweed	cf	seed	a	no	u	1	
.25-32	*Chenopodium/amaranthus*	cheno-am	cf	seedcoat	cf	no	u	1	
.25-32	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-33	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-33	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-34	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-34	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-35	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-36	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-36	***Portulaca***	**purslane**	**a**	**seed**	**a**	**no**	**c**	**1**	**(.25-8)**
.25-36	*Chenopodium/amaranthus*	cheno-am	t	seed	a	no	u	1	
.25-37	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-37	unknown botanical	unknown	t	disseminule	t	no	u	2	
.25-37	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	1	
.25-37	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-38	*Silene*	catchfly/campion-type	a	seed	a	no	u	16	
.25-38	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	1	
.25-39	unknown botanical	unknown	t	seedcoat	t	no	u	1	
.25-39	*Silene*	catchfly/campion-type	a	seed	a	no	u	5	
.25-39	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-40	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	a	no	u	2	
.25-40	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-40	unknown botanical	unknown, ovoid	t	seed	t	no	u	1	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-40	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-41	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-41	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	3	
.25-42	*Silene*	catchfly/campion-type	a	seed	a	no	u	15	
.25-42	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-42	unknown botanical	unknown	t	disseminule	t	no	u	1	
.25-42	unknown botanical	unknown, ovoid	t	seed	t	no	u	1	
.25-43	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-43	unknown botanical	unknown, round	t	seedcoat	t	no	u	1	
.25-43	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-44	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-44	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-45	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-45	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	2	
.25-46	*Silene*	catchfly/campion-type	a	seed	a	no	u	10	
.25-46	***Origanum vulgare***	**oregano**	**a**	**seed**	**a**	**no**	**c**	**1**	**(.25-27)**
.25-46	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-46	unknown botanical	seed/achene	t	seed/achene	t	no	u	1	*Artemisia* (cf)
.25-46	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-47	*Silene*	catchfly/campion-type	a	seed	a	no	u	13	
.25-47	unknown botanical	unknown, round	t	seed	t	no	u	1	
.25-47	*Myosotis*	forget-me-not	a	seed	a	no	u	1	
.25-47	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-48	*Myosotis*	forget-me-not	a	seedcoat	a	no	u	2	
.25-48	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-48	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-48	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	2	
.25-49	*Verbascum thapsus*	common mullein	a	seed	a	no	u	2	
.25-49	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-50	*Silene*	catchfly/campion-type	a	seed	a	no	u	9	
.25-50	*Myosotis*	forget-me-not	a	seed	a	no	u	2	
.25-50	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-51	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-52	*Silene*	catchfly/campion-type	a	seed	a	no	u	12	
.25-52	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	3	

continued…

Table A.6 Experiment 2, firepit 5 data: flotation sample 5 exotic recovery summary, continued.

Screen size/ subsample number	Scientific name	Common name	C[a]	Part	C[a]	Frag[b]	Cond[c]	Count	Notes/found previously
.25 mm light fraction screen using species area curve subsampling, entire portion examined (previous observations noted by screen/subsample if applicable) continued									
.25-52	unknown botanical	disseminule	t	disseminule	t	no	u	1+	
.25-52	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-53	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-53	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-53	unknown botanical	unknown, ovoid	t	seedcoat	t	no	u	1	
.25-54	*Silene*	catchfly/campion-type	a	seed	a	no	u	4	
.25-54	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-54	*Chenopodium/amaranthus*	cheno-am	t	seedcoat	t	no	u	2	
.25-54	*Lepidium*-type	pepperweed	cf	seedcoat	t	no	u	2	
.25-55	*Lepidium*-type	pepperweed	cf	seedcoat	t	no	u	1	
.25-55	*Silene*	catchfly/campion-type	a	seed	a	no	u	2	
.25-55	*Plantago*-like	plantain-like	cf	seed	a	no	u	1	
.25-56	*Silene*	catchfly/campion-type	a	seed	a	no	u	3	
.25-56	unknown botanical	unknown	cf	inflorescence	cf	no	u	1	*Artemisia* (cf)
.25-57	*Silene*	catchfly/campion-type	a	seed	a	no	u	7	
.25-57	*Centaurea* (*diffusa/maculosa*-type)	diffuse/spotted knapweed	cf	achene	cf	no	u	1	
.25-57	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-58	*Silene*	catchfly/campion-type	a	seed	a	no	u	6	
.25-59	*Silene*	catchfly/campion-type	a	seed	a	no	u	8	
.25-59	*Verbascum thapsus*	common mullein	a	seed	a	no	u	1	
.25-59	unknown botanical	unknown	cf	seedcoat	cf	no	u	1	
.25-59	unknown botanical	unknown	t	inflorescence	t	no	u	1	*Artemisia* (cf)

Notes
[a] "C" Analyst confidence: a (absolute); t (tentative); cf (compares favourably).
[b] "Frag" Fragment: yes/no.
[c] "Cond" Condition: c (charred); u (uncharred); pc (partially charred).
† specimens that would be unrecognized under normal conditions.

Appendix B: Symbolic associations—the cultural significance of colour and direction in Pueblo cosmology

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Animals and Birds (see also Muir 1999)							
[Hopi] *Eleodes* sp.		One of hundreds of species of darkling beetle	Black	Northwest	Associated with the Snake-Lizard Phratry and Snake Dance priests and ceremonial purification (39).	The *Eleodes* beetle is one of two animals that "do not have souls of their own. Their bodies are occupied by the dark souls of wicked people who have lived on the earth and are thus being punished…the other is a small night moth, who so often casts himself into the flames of your campfire. When these animals perish, they are blotted out, for their dark souls perish with them" (7). Snake Dance priests use this medicine and this is "why the dancers do not suffer from snake bite." (39).	Whiting (1939:7, 39)
[Hopi, Zuni, Keresan, Jemez, Tewa, Isleta, Picuris, Taos Pueblos] Mountain lion, Oriole			Yellow [Hopi, Zuni, Keresan, Jemez]	North		Tewa and Taos recognize blue and Isleta and Picuris recognize black as the colours associated with the north.	Dozier (1983:205-206)
[as above] Bear, Bluebird			Blue [Hopi, Zuni, Keresan, Jemez]	West		Acoma and Laguna Pueblos also include Weasel as associated with the west direction. Tewa, Isleta, Picuris and Taos recognize yellow as associated with the west direction.	Dozier (1983:205-206)
[Hopi, Keresan, Jemez, Isleta, Picuris, Taos] Wildcat, Parrot			Red [Hopi, Zuni, Keresan, Jemez, Tewa]	South		Zuni and Tewa recognize Badger as associated with the south direction and do not recognize Wildcat. Isleta recognizes buff and Picuris and Taos recognize blue as the colour of the south direction.	Dozier (1983:205-206)
[Hopi, Zuni, Keresan, Jemez, Tewa, Isleta, Picuris, Taos] Wolf, Magpie			White	East		All pueblos recognize white as the colour associated with the east direction.	Dozier (1983:205-206)
[Hopi (Western?)] Tanager [Zuni, Keresan, Jemez, Tewa] Eagle			Black All colours	Zenith		Hopi recognize black and Zuni, Jemez, Tewa recognize all colours as associated with the zenith.	Dozier (1983:205-206)
[Hopi, Zuni, Keresan, Jemez, Tewa] Mole			All colours Black	Nadir		Hopi recognize all colours with the Nadir. Zuni, Keresan, Jemez, and Tewa recognize black.	Dozier (1983:205-206)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Domesticated plants							
[Hopi] *Phaseolus acutifolius latifolius* Freeman	***₃´tca´tcai´mori*** *tcatcai´*:small *mori*: bean (109); "white, light bean"	White tepary bean	White	Northeast	*Powamuy* (bean) ceremony	An old bean cultivated "for a long time." Used in the first salted dish eaten by a priest of the *Powamu* (bean) ceremony after a ritual fast. Parched. If not available other white beans will be used.	Whiting (1939:80)
[Hopi] *Phaseolus lunatus* L.	***Hati´qo***	Lima bean identified as "white," "gray," "yellow," "red," "black"		Unknown	*Powamuy* (bean) ceremony	Planted in the "super-heated" kivas during the *Powamu* ceremonies in February. Because of their large size they are most preferred and recognized as "species" by colour recorded in naming conventions. The success or failure of this kiva crop is thought to foreshadow the season to follow (81).	Whiting (1939:81)
[Hopi] ***Phaseolus vulgaris* L.**	***Q₃ma´fva´pu*** "dark bean"	purple string bean	light lavender, mottled	Unknown	*Powamuy* (bean) ceremony	"Cultivated by the Hopi for a long time" (82). *Me´y'ingwa*, the spirit of germination sends the seeds up through the soil form the underworld. The spirit rolled the pods in his hands giving them their shape (Stephen 1936 in Whiting 1939:82). Ground sweet corn meal is moulded into the shape of the pods and dyed with purple corn (*koko´ma* and then hung on sprouted beans in the kiva as an early kiva crop (82).	Whiting (1939:82)
[Hopi] *Zea mays saccarata* Sturt.	*Tawa'ktci* the meaning is obscure and not associated with the Hopi words, *katsina* and *ta'wa* (sun)(69)	Sweet corn	All colours or grey	Nadir	*Niman* (*Katsina* home going) ceremony	*Niman katsinas* signal the end of planting season. They visit the pueblos this one last time during the year and bring with them the first harvested corn of the season (usually sweet corn) that was planted early and secretively in a protected location. This is given to uninitiated children (Whiting 1939:67-68). Planting and harvesting are "kept secret from the children" (Stephen 1936:373).	Stephen (1936:373) Whiting (1939:45, 69)
[Hopi] *Zea mays amylacea* Sturt. Soft/flour maize	*Q3tca'aq"₃*	Flour corn, (several varieties)	White	Northeast	See also *Zea mays* L.	See *Zea mays* L. entries. Varieties are based on size and origin.	Whiting (1939:69)
[Hopi] *Zea mays amylacea* Sturt. Soft/flour maize	*Taku'ri*	Yellow corn	Yellow	Northwest		"Grown chiefly as a source of early green corn. Used for mush because it 'tastes stronger than other varieties.' Ceremonially associated with the northwest direction (69)."	Whiting (1939:69)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Domesticated plants							
[Hopi] *Zea mays amylacea* Sturt. Soft/flour maize	*Pala′tspipi*	Red corn	Red	Southwest	Ceremonially associated with the southwest direction	"A red ear of corn is allowed to remain in the place where the person died, for four days, when it is stuck in the ceiling immediately over the place where it had been lying. If it is still there next planting season, he who has the bravest heart takes it out and plants it (Stephen 1936:828).	Stephen (1936:828) Whiting (1939:68)
[Hopi] *Zea mays amylacea* Sturt. Soft/flour maize	*Sakwa′fqa′′*$_3$ *Kwa:′qa'*$_3$ (flying eagle corn)	Blue corn, several varieties including "flying eagle corn," a mix of blue and white kernels	Blue	Southwest	*Piki* bread	"Next to white corn, blue corn is the most important Hopi crop. Every family raises at least one type" (67). Used to make blue *piki* (wafer) bread. The blue colour in the corn is mixed with the ashes of *Atriplex canescens* to make a deep blue-green colour. Flying eagle corn was apparently obtained from the Havasupai at the San Diego exposition in 1915, others are much older (68).	Whiting (1939:67-68)
[Hopi] *Zea mays amylacea* Sturt. Soft/flour maize	*Koko′ma*	Purple corn	Purple/black	Zenith	*Powamuy* (bean) ceremony	In February beans are planted in boxes in kivas. Finely ground sweet cornmeal is dyed made from purple corn and shaped to imitate purple string beans and are attached to the stalks of sprouted beans as part of the ceremony. The success of this "kiva crop" is thought to "foreshadow the harvest of the coming season" (Whiting 1939: 41). Due to staining *koko′ma* is rarely eaten but used as a dye for basketry, textiles, body paint by some *katsina* dancers.	Whiting (1939:40, 69)
"Wild" plants							
[Hopi] *Abies concolor* Abies concolor (Gord. & Glend.) Lindl.ex Hildebr.	*He'kwpa*	White fir/ White fir	White	Southwest	Clan name in the Kachina-Cottonwood phratry	Found on the higher slopes of the San Francisco mountains, associated with katsinas, clouds, and rain. Ritually smoked.	Whiting (1939:62) Stephen (1936)
[Hopi] *Anogra runcinata Oenothera albicaulis* Pursh	*Poli:'si* white butterfly	White evening primrose	White	Northeast	Ceremonially important as the "White Flower" of the northeast direction		Whiting (1939:86)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
"Wild" plants continued							
[Hopi] *Artemisia filifolia* Torr.	*Hova'kpi* Sand sagebrush	Sand sagebrush	Blue or green	Southwest	*Powamuy* (bean) ceremony	Associated with the *Powamuy* altar	Voth (1901) Whiting (1939:94)
[Hopi] *Atriplex canescens* (Pursh) Nutt.	*Su'ovi/süóvi* (Whiting 1939:38/Hough 1897:21); *Cüovi* (Fewkes 1896:21). From the word *cükü/* pungent.	Four-wing saltbush	Unrecorded presumed blue based on colouring of *piki* bread and kiva fuel	Unrecorded presumed blue based on colouring of *piki* bread and kiva fuel	Ceremonial kiva fuel	Ashes used to colour *piki* bread blue/grey. "one of the four prescribed *kivamyakohü*, (kiva fuel)." Used in the making of *pahos* (prayer sticks).	Fewkes (1896:18, 21, 39) Hough (1897:42) Whiting (1939:73)
[Hopi] *Aster leucelene* Blake, also noted by Whiting (1939:95) as *Aster ericaefolius* Rothr.	*To:'tim*, meaning "boys" (Whiting 1939); *Ho'n'ngapi* meaning "the bear charm" (Stephen 1936)	White aster	White	Zenith ("the celestial space directly above the observer")	Part of Snake Dance emetic (Whiting 1939:39); "Bear medicine" root -trans-formation of Bear shamans (Parsons 1996 [1939])	A medicinal stimulant (Whiting 1939:31) and respiratory medicine (34). Generally not recognized by Whiting's informants (39). Associated with the zenith (the celestial space directly above an observer) and through that association presumably the colour black and purple corn (Whiting 1939:45). Noted as a narcotic root used by Bear shamans to transform into bears and allow them to diagnose disease (Parsons 1996 [1939])	Parsons (1996 [1939]:189) Stephen (1936:99) Whiting (1939:31, 34, 39, 45, 95)
[Hopi] *Astragalus* sp.	*Momo'nga*		Loco weed (?)	Southeast	Snake-Lizard phratry, snake dance emetic	Associated with the Snake-Lizard Phratry)(39). One of the ingredients of the Snake Dance emetic. A digestive medicine also.	Stephen (1936:711) Whiting (1939:20, 80)
[Hopi] *Calochortus aureus* S. Watson	*He:'si*	Mariposa lily golden mariposa lily	Yellow	Northwest	*Powamuy* (bean) ceremony Name of a clan of the Snake-lizard phratry	Seeds and flowers are ground to make "yellow pollen." The bulbs were eaten and in historic times, reproductions were made of yellow paper and used in *Powa'mu* ceremonies in February. Flowers are also essential elements of *pahos* (prayer sticks).	Stephen (1936:248; 1216) Whiting (1939:70)
[Hopi] *Castilleja linariaefolia* Benth.	*Ma'nsi* *Pala'mansi*	Painted cup Indian paintbrush	Red	Southeast	"Red Flower" Name of a clan in the Snake-lizard phratry	Flowers are essential element of *pahos*. An orange colored paint for artificial squash blossoms is made from this plant.	Whiting (1939:91)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Wild plants continued							
[Hopi] *Chrysothamnus* spp., also known as *Bigelovia howardii*	*Siva'pi:* *sivwapi* from *sikyanpu* (yellow); *vwuvwapi* (whip)	Green rabbitbrush as distinguished from grey rabbitbrush	Yellow Green	Northwest	A clan of the Water-corn phratry. Also associated with the Northeast in the *Powamuy* altar, the zenith and nadir in the *Oaqol* (women's) ceremony	"One of the four prescribed *kivamyakohü* (kiva fuel)." The yellow flowers used to make a yellow dye or pigment used for personal decoration (Whiting 1939:95). Voth (1903:3) notes that the *Oaqol Society* was lead by and owned by the Sand clan at Orayvi. The *Oaqol* is one of three women's ceremonies.	Fewkes (1896:18, 20) Hough (1897:42) Voth (1901:76; 1905a:28) Whiting (1939:38, 95)
[Hopi] *Chrysothamnus* spp.,/*Bigelovia howardii*	*Masi-sivapi*	Gray rabbitbrush	White	Northeast	Water-corn phratry	See above.	See above.
[Hopi] *Cowania stansburiana* Torr.	*Hu:'nvi*	Cliffrose	Red	Southeast	*Powamuy* altar	"In the old days the cradle board was padded with the bark from the larger stems" which have sometimes been mistaken for juniper bark (Whiting 1939:78). Snake priests kilts are made from the bark (78). Easily confused with bitterbrush and contemporary groups do not distinguish between them (*Purshia tridentata*-type)(Dunmire and Tierney 1997:168-170)	Dunmire and Tierney 1997:168-170) Whiting (1939:78)
[Zuni] *Cycloloma atriplicifolium* (Spreng.) Coulter	*A'kwaluptsine* "yellow medicine"	Winged pigweed	Yellow	Unrecorded but presumed associated with war/war brothers	Belongs to the Grandmother of the Gods of War	Spider grandmother gave this medicine to the War Brothers "with instructions that when near the enemy they should" chew the blossoms of the plant, eject the material in to their hands and rub well. This sends out a "peculiar yellow light spread over the world, preventing the enemy from seeing how to aim their arrows truly. This medicine was exclusively in the keeping of the late Nai'uchi and his ceremonial brother, Me'she, who were the earthly representatives of the Gods of War. The secret of its use passed away with their death, as they did not see fit to confide it to others of the Bow Priesthood"(84).	Stevenson (1915:84)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Wild plants continued							
[Hopi] *Delphinium scaposum* Greene -	*Tcoro'si* *Tukya'msi* "prairie dog blossom"	Larkspur Tall mountain larkspur	Blue or green	Southwest	A clan of the Snake-lizard phratry; *Powamuy* ceremony	Flowers are essential element of *pahos*. Often appears in personal names given by women belonging to this phratry. Taken as an emetic for *Powamuy* (bean) ceremony.	Voth (1901:107; 1905c:112) Whiting (1939:76)
[Hopi] *Hymenopappus lugens*	*Hekwe'fnga*		Unrecorded —white?	Northeast	Water-corn phratry; Snake Dance emetic	Associated with the Water-corn Phratry. The root is used for tooth decay (Whiting 1939:33) and was not recognized by most of Whiting's informants (50). One of the plants used in the Snake Dance emetic.	Whiting (1939:33, 39, 50, 97)
[Hopi] *Juniperus* spp.	*Ho'tcki* (tree); *Lepo'si* (berry); *Ho'ko* (wood); *Ho'hu* (tree and wood); *Ho'lpe* (bark); *Nguma''pi* (branch); *Ko'kof* (cedarwood/ charcoal?)	Juniper	Unrecorded — white?	Northeast	*Qaqol* (women's) ceremony; Juniper clan names (*Ho'ko* and *Ko'kof*) in Fire-Coyote Phratry	The use of juniper in fires increased with the introduction of the steel axe (Whiting 1939:62). Hopi are against the cutting of green wood for firewood, the concern for overharvesting is evident, causing erosion and the destruction of nearby springs (62). Used for construction, firewood, bark for tinder, medicine, purification, body paint, tools, berries for jewelry (in ancient times) and as food (63).	Voth (1905a:28) Whiting (1939:47)
[Hopi] *Lesquerella intermedia* (see also "Animals, *Eleodes*"	*Hohoi'ya'wnga* Named for the black beetle (*Eleodes* sp. (77).	Bladderpod (root)	Black	Southwest	Ceremonial emetic taken with *Eleodes* sp. (black beetle); *Katsina*-Cottonwood phratry; *Powamuy* altar	Considered specific for snakebite (root and beetle)[Hopi]. "Each man carries some of this while hunting snakes. If one bites him he eats a little of the root, chews it a little and lays it on the wound, and no harm ensues. An infusion of the same root, is drunk and then acts as an emetic, as a purification at the end of the public [snake dance] ceremony" (Stephen 1936:724).	Stephen (1936:0724) Whiting (1939:39, 77)
[Hopi] *Odostemon fremontii* (Torr.) Rydb. now *Mahonia fremontii* (Torr.) Fedde	*Ho:'nyavi* *Ho'ngwi* (Oregon Grape)	Fremont's mahonia previously "Holly Grape"	Presumed red based on southeast direction	Southeast	Oaqol (women's) ceremony	Yellow wood is used for many tools and as medicine for the gums.	Whiting (1939:76)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Wild plants continued							
[Hopi] *Onosmodium thurberi* A. Gray Also known as: *Macromeria viridiflora*	*Yoi´viva* Sacred tobacco	Thurber's giant-trumpets	White	Presumed based on colour	Ceremonial tobacco most effective for bringing rain	Long white tubular flowers. Occurs occasionally "in the higher altitudes...the gathering of this plant is accompanied with prayer and an offering of corn meal. The leaves, stems, and flowers are dried, pulverized, and mixed with native tobacco (*Nicotiana* spp.)" (88). This species is most effective for bringing rain.	Whiting (1939:88)
Pinus edulis Engelm. *Pinus monophylla* Torr. & Frem.	*Ho:qa''$_3$* *Na'sh$_3$* (branch) *Sa'na* (gum)	Pinyon pine	Presumed based on clan association	Presumed based on clan association	Name of a clan in the Fire-coyote phratry; associated with *katsina*	Symbolically linked with fire and juniper (fire-juniper-pinyon association). Used in ritual purification and medicine. The Pinyon clan and Juniper clan are linked in the Fire-Coyote phratry (3).	Whiting (1939:3, 63, 72)
Populus spp.	*S$_3$h$_3$'vi*	Cottonwood	Unknown but presumed	Unknown but presumed	*Niman katsina* (home going ceremony)	Hand-carved dolls are given to the children with the first corn harvest during *Niman* ceremony. Branches are used in the Snake Dance and other related ceremonies (Whiting 1939:72)	Whiting (1939:72)
Pseudotsuga mucronata (Raf.) Sudw.; *Pseudotsuga taxifolia* Britton; *Pseudotsuga menziesii*	*Sala'vi*	Douglas fir	Yellow	Northwest	A clan name in the *Katsina*-Cottonwood phratry	Ritually smoked. Found in the high ranges of the San Francisco Peaks, Arizona where the *katsinas* live. "If the boughs gathered in the spring are glossy green, there will be plenty of rain and no bad winds, while a dull gray appearance harbors evil for the coming summer" (Stephen 1939:395)	Stephen (1939:395) Whiting (1939:45, 63)
Quercus spp.	*Kwi:'ngvi*	Oak	Yellow	Northwest	*Oaqol* (women's) ceremony; A clan of the Mustard phratry	Used as a wood for tool making (rabbit sticks, arrow, bows, digging sticks etc.)	Voth (1905a:28) Whiting (1939:72)
Rhus trilobata	*Cübi* from *cükü* meaning pungent	Sumac; lemonade-berry	Presumed based on use as a sacred kiva fuel	Presumed based on use as a sacred kiva fuel	Ceremonial kiva fuel and ceremonial associations	Twigs were used for ceremonial purposes, "one of the four prescribed *kivamyakohü*, (kiva fuel)." For basketry. The buds are considered medicinal.	Fewkes (1896:16, 18) Hough (1897:42) Whiting (1939:38)

continued…

Table B.1 Colour and directional symbolism recorded in a selection of historic ethnographic sources, continued.

Genus/species[a]	Hopi name and translation[b]	Common name	Colour	Directional associations	Social significance[d]	Traditional and historic uses	Sources
Wild plants continued							
Sarcobatus vermiculatus	*Te:'ve*	Greasewood	Presumed based on use as a sacred kiva fuel	Presumed based on use as a sacred kiva fuel	Chief kiva fuel; Name of a clan in the Eagle-Sun phratry, sometimes associated with Water-Corn phratry (74)	"One of the four prescribed *kivamyakohü*, (kiva fuel) and the principle one used," a "chief kiva fuel" – "burns bright with a sparkling flame" (Whiting 1939:74).	Fewkes (1896:18) Whiting (1939:74)
Salix spp. possibly *Salix laevigata* Bebb "red willow"	*Qaha'vi*	Red willow "red willow"	Red	Southeast	*Oaqol* (women's) ceremony	There are several kinds of willow differentiated by the Hopi by the colour of the bark: red, green, yellow and gray. The wood is used in roof construction, making *pahos*, and in ceremonies.	Stephens (1936:668) Voth (1905a:28) Whiting (1939:72)
Yucca angustissima Engelm.	*Mo'hu* (top of the plant) *Mo:vi* (roots)	Narrow-leaved yucca	All colours or grey	Nadir	Purification prior to ceremony; Owned by the Agave Clan (Voth 1905c:93); Name of a clan of the Fire-Coyote phratry (Whiting 1939:71)	Roots are crushed to make soap suds. Suds are associated with clouds and *katsinas*. Leaves are used as whips in purification ceremonies (Whiting 1939:77).	Voth (1905c:93) Whiting (1939:45;77)

Notes:

[a] the first genus/species designations are recorded by Whiting (1939) and may be out of date. I interpret these with newer designations (second entry) gleaned from the USDAPlants website (2015) wherever possible.

[b] Hopi names are taken only from Whiting (1939). Some symbols in the original spelling are omitted.

[c] Common names documented in Whiting (1939) are linked to reasonable assessments of contemporary common names (sentry in bold).

[d] Phratries are defined in Barfield, ed. (1997:359) as, three or more sets of clans related by common descent or other kinship alliances.

Appendix C: Identification criteria for plant and other archaeological remains

The criteria used to identify plant remains recovered from Sand Canyon Pueblo archaeobotanical samples are presented here, listed alphabetically by type, family, genera/species and part. Materials that were unidentified to genus or species are described. All classifications and descriptions are based on observed morphology using specific surface characteristics, internal structures, shape and size. Identifications were supported by comparisons with various collections: 1) my charred and uncharred collection from Cortez, Colorado, and British Columbia; 2) Crow Canyon Archaeological Center (CCAC) comparative collection (Adams and Adams 1987); and, 3) herbaria voucher specimens from CCAC, University of Victoria Herbarium, and borrowed vouchers from Agriculture and Agri-food Canada, Kamloops, B.C. Identification descriptions are adapted or taken directly from Adams and Murray (2004). Information on the potential ethnographic use of plants is based on Rainey and Adams (2004) unless otherwise specified. I focus for the most part on documented use of plants by the Hopi people because of the proximity of the Hopi mesas to Sand Canyon, however, other Pueblo groups claim ancestral connections with Sand Canyon Pueblo. The ethnographic record encompasses many traditions that are equally valid but in the interests of space may not be included. The information presented here is not intended to suggest or support a specific cultural association.

Domesticated plants: Monocotyledonae

***Poaceae* (Grass Family)**

Zea mays (maize/corn)

The cultural and economic importance of maize cannot be understated in the American Southwest. The significance of the plant to Pueblo people today as in the past should be explored when interpreting how corn evidence comes to be recovered in archaeological deposits. Some basic uses of corn are presented here. Whole and ground kernels can be used for meal, flour, and dough (see Adams, J. (1999) for a study of ground maize and food grinding processes. Cobs are recorded as being used for fuel (Rainey and Adams 2004). The Hopi use the ears for food and as important objects in ceremonies (Ortiz's 1969 descriptions of the role of "Corn Mothers" is an important study). Rainey and Adams (2004) also note that corn kernels were mixed with *Rhus* [Sumac] berries to make a body paint. The Hopi are recorded as using special pink corn (*Zea mays* L. var. *amylacea*) in paint for kachinas. Stevenson (1915:99) records that the Zuni used corn colors for the cardinal points:

“yellow for the north, blue for the west, red for the south, white for the east…” Whiting (1939:47) notes the use of the plant as a Hopi clan name. Two important resources for exploring corn are Ortiz (1969) as previously mentioned, and Ford (1980). Both examine corn from ideological perspectives where the colour of the kernels is of primary importance, not only for cultural preference of palatability as food, but also for the ordering of pueblo social life (see Appendix B). The morphological kernel traits of flour, flint, and dent that can be seen archaeologically, were not necessarily culturally important in decisions about corn use in cases where decisions privileged colour, particularly in association with specific ceremony, colour being a characteristic that is invisible archaeologically (Ford 1980).

Cob fragment. A piece of cob that is incomplete in circumference and incomplete in length. No specimens identified as cob fragments have kernels attached and are, therefore, interpreted to represent the secondary use of *Zea mays* cobs and as fuel (Adams 1993b; Rainey and Adams 2004).

Cob segment. A piece of cob that is complete in circumference and incomplete in length. None have kernels attached and therefore interpreted here to represent the secondary use of *Zea mays* as fuel (Adams 1993b; Rainey and Adams 2004).

Cupule. Durable cuplike structure that holds a pair of kernels. Rectangular in shape, cupules often have irregular edges and can vary in size. Cupules are typically interpreted to represent secondary use of *Zea mays* for fuel (Adams 1993b; Rainey and Adams 2004).

Glume. Lens-shaped papery or hard bracts normally located on a cupule. Quadrangular or rectangular in face view (Adams and Murray 2004), fine hairs may be present on the irregularly shaped margins and sometimes seen archaeologically. Surfaces are generally smooth although some display husk striations where the surrounding leaves have pressed into the kernel. Glumes are typically interpreted to represent remnants of the use of *Zea mays* cobs as fuel (Adams 1993a; Rainey and Adams 2004). I interpret glume remains as potential evidence of the initial processing of maize for flour particularly when found in association with kernel fragments. Photograph D.1 (Appendix D).

Kernel. Both immature and mature kernels were observed in Sand Canyon samples. No evidence of husk striations on the surfaces was noted. All kernels are separate with either fine grained or porous endosperm suggesting pop/flint and flour type maize. The presence of kernels is interpreted as evidence of the use of *Zea mays* for food (Adams 1993a; Rainey and Adams 2004).

Kernel embryo. Conforming to Adams and Murray's (2004) description, kernel embryos are oval to irregular in face view, triangular to wedge-shaped on cross-section. Embryos show a longitudinal opening on the exterior where a minute, cylindrical future bud can be seen (Adams and Murray 2004). This is referred to as the "growing tip" and in some specimens is quite elongated (photographs D.2 and D.3 [Appendix D]). The exterior surface is smooth. Generally the size is 3-6 mm or less. In some cases the specimens were found in the smallest screen sizes (.71 and .25 mm portions) suggesting that the kernels were originally very small or shrank with charring. I interpret kernel embryo remains as representing the processing of maize for meal or flour.

Domesticated plants: Dicotyledonae

Cucurbitaceae (Cucumber Family)

Cucurbita-type (gourd)

Cucurbita (squash/gourd) seeds, rinds, roots, flowers, and leaves were used for a variety of purposes that include food, medicine, and ceremony (Moerman 1998). The seeds are recorded as being ground to oil *piki*[146] stones by the Hopi (Cushing 1920:305, 332) who also dried and stored the meat for winter use (Rainey and Adams 2004). Stevenson (1915:62) documents the Zuni grinding the seeds of *Cucurbita* with *Xanthium commune* Britton (cocklebur) and corn grains for medicine to heal wounds. Almost all squash seeds recovered in the new Sand Canyon samples were ground and incomplete, some were charred, others were not. Some specimens were found in association with *Physalis longifolia*-type seeds (charred and uncharred) in midden 1214, sample FV14, examples of the excellent preservation conditions so notable for Sand Canyon Pueblo.

Parenchyma. These are more or less spherical thin-walled simple cells (Stern et al 2003:55) that make up the inner tissue. Specimens identified as parenchyma match comparative *Cucurbita* material and were found in association with other gourd/squash remains such as seeds and seed coats.

Peduncle. The stalk. The peduncle measures 1.5 cm in height with a slight pointed flare at the attachment point, 2 cm in diameter at the base, and 1.4 cm at the tip, which is broken. The furrows are fine, shallow, and very smooth. The stalk compares favourably to *C. moschata* (based on Cutler and Whitaker 1961:478). Taking the conservative view, however, the specimen is identified to *Cucurbita*-type.

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[146] Paper-thin *he'we* or wafer bread made on especially prepared baking stones with the batter consisting of a variety of finely ground corn. Piki bread can be colored blue depending on the additional of saltbush (*Atriplex*)(Cushing 1920: 305, 332).

Rind. Rind fragments identified as *Cucurbita*-type are based on cross-section view of inner rind cells. Located several layers beneath the hard "stone" cells known as sclereids found just under the surface rind of the plant (Cutler and Whitaker 1961:478), the cells are large, thin-walled, and isodiametric. They are regularly arranged.

Seed/seed coat. Found in fragments, the seeds appear to have been deliberately crushed. This identification also applies to those fragments of *Cucurbita* sp. seeds that occur in smaller portion screen sizes such as .71 and .25 mm light fraction portions.

Cucurbita moschata-type (butternut/winter crookneck squash)

Seed/seed coat. Specimens are broken and appear to crushed or ground. Edges are rounded with wavy fringes typical of *C. moschata*. Cutler and Whitaker (1961:478) note that *C. moschata* occurs abundantly in archaeological contexts after A.D. 1100 identified on the basis of thin, ragged and wavy fringes along the seed margins (photograph D.4-D.6, Appendix D).

Cucurbita pepo-type (field pumpkin)

Seed. Identification of *C. pepo*-type seeds is based on Cutler and Whitaker (1961). Seeds of field pumpkin have smooth seed margins lacking the thin, ragged, and wavy margin fringes diagnostic of *C. moschata*-type seeds. Most seeds are almost whole and appear to have been intentionally broken.

Lagenaria-type (gourd/bottlegourd)

The ethnographic record indicates that bottlegourd was an important source of food, medicine, and other uses historically. The Hopi are noted as using the plant for prayer sticks, containers, cooking and hunting tools, decorations, and musical instruments (Moerman 1998:294-295).

Rind. Identified as *Lagenaria*-type rind based on cross-section view of the internal characteristics of the inner layer cells. These cells are located almost immediately below the surface rind layer and are large, elongated, and loosely organized (Cutler and Whitaker 1961:479). They differ enough from *Cucurbita*-type cells to be almost immediately recognized.

Fabaceae *(Pea Family)*

Phaseolus vulgaris-type (common/kidney bean)

Phaseolus vulgaris was cultivated in the prehistoric Southwest (Kaplan 1956). The few common beans recovered at Sand Canyon Pueblo may be explained by a lack of the resource, poor preservation (beans do not preserve well even when charred) or preparation through boiling (Adams 1993a). Bean remains are associated with the last events at SCP and were found unusual abundance in abandonment contexts.

Cotyledon. Elliptic, oval, or reniform in face view. A cotyledon represents one-half of a bean that has naturally split into two equal portions (Adams and Murray 2004).

Seed/bean. Elliptic, or oval, or reniform in face view. Specimens are oval in cross section with the hilum (the notched attachment point) on one edge near the center (Adams and Murray 2004). Specimens vary in surface texture and shape, measuring 1-1.1 cm in length and 4-7 mm in width. One specimen has a slightly pitted surface texture, another a smooth surface (photographs D.7 and D.8, Appendix D).

Wild plants: Gymnospermae

Gymnosperms

The Hopi told of a story of corn, wild seeds and the "Emergence" when seven peoples emerged from the underworld: the *Pahano* (white people), *Hopi*, *Yota, Yochemu, Tashabu, Yotahuni* (the old name for Navaho) and *Payutsi*…

> People brought no corn up the sipapü; there was no corn. People were constantly thinking and saying, 'What shall we eat?' *Mü*^{r}*iyinwu*, the underworld male spirit of corn and vegetation, offered to each of the emerging peoples, one of six kinds of corn that grew in the underworld for their use in the new world: yellow, blue, red, white, black and spotted corn. The Hopi took the smallest ear, the sweet corn (*tüwakchi*). For this choice, the spirit said, 'you shall have the kachina and their knowledge.' There was not enough corn to go around and in the end, the *Payutsi* said, 'I don't want any corn, I can live very well on grass seeds and cactus fruit' (Adapted from Alexander M. Stephen's *Hopi Tales*, "The Emergence," as told by Honi of the Cactus maternal family of the Snake clan, Crier chief [Stephen 1929:7-8]).

<u>Gymnosperm, unknown</u>

Pith. Specimens identified to this category compare favorably to central soft tissue found in wood, or the xylem cells that surround the pith.

Wood (charcoal). Identification based on the presence of cells (tracheids) typical of gymnosperms. Specimens identified to this category are too degraded or fragmented to identify genera. The presence of tracheids and, in some cases, resin canals clearly indicate a gymnosperm.

Cupressaceae *(Cypress Family)*

Juniper/Cedar

The ethnographic record notes the use of juniper by many Native American groups in a variety of ways. The Hopi in particular exploited various species of juniper for food, fuel, medicine, and construction material (Rainey and Adams 2004). Whiting (1939:47) records the Hopi clan names, two for Juniper (*Juniperus utahensis*) suggesting its importance to the Hopi in the recent past. Documentation of *J. utahensis* as a tinder material is also noted by Whiting (1939:23). Stevenson (1915:55) documents the use of *Juniperus monosperma* (Engelm.) Sargent., as *Ho'mane,* the Zuni word for cedar (*Ho'mawe* is the word used when referring to the tree as medicine). The twigs were used for a medicinal tea, first roasted in a fire, steeped in hot water and drunk by women pre-partum and post partum. In combination with juniper mistletoe (Zuni: *o'lipoli*; *Phoradendron juniperinum* Engelm.),[147] the tea was thought to be an effective muscle relaxant. Juniper is recorded as part of cleansing activities after death and burial (Whiting 1939:3). The Juniper Clan, the association of fire-juniper-pinyon (*Pinus edulis*) and Fire-Coyote phratry signifies the social importance of juniper to the Hopi (3).

Juniperus osteosperma-type (Utah juniper)

Scale Leaf. Specimens identified as juniper scale leaves are smooth, triangular to lens-shaped in face view that thicken to a pointed tip. Outer margins are denticulate and overlap on the twig. Leaves typically measure 3 mm or less (Adams and Murray 2004). The presence of scale leaves is interpreted to represent the cultural use of this material as tinder (Adams et al. 2007) although the practice of applying bundles of juniper twigs to wounds, for medicinal teas, and using juniper smoke for cleansing (as noted previously) suggest that juniper twigs have deeper cultural meaning.

Seed. A single modified charred *Juniperus osteosperma*-type seed was recovered from new Sand Canyon sample, FV14. A hole drilled through the seed resulted in some radial breakage. Juniper seed bead making from at least Basketmaker times (Adams and Paterson 2011) indicate that this seed was intended for use as jewelry and discarded because of the flaw. Identification to *J. osteosperma* is based on the morphological similarities of the specimen and this juniper species, common in the Sand Canyon area today (photographs D.9-D.11).

[147] Hough (1897:41) records the Hopi use of juniper mistletoe as a coffee-like beverage. "A larger species," of mistletoe is found on cottonwood trees called *lo mapi* by the Hopi, is used as a medicine.

Twig. Covered with whorls of two to three overlapping lens-shaped leaves with denticulate margins.

Juniperus-type (juniper, not Utah juniper)

Bark fragments. Specimens are shredded, both charred and uncharred, and compare well to comparative materials from collections taken in 2008 and 2009 in Cortez.

Cone (male). A reproductive structure composed of a branch with triangular/wedge-shaped scales. Male cones have a fleshy bump on one surface of the scale that is sometimes visible (Adams and Murray 2004). The surface is smooth. Specimens identified to this category match the author's comparative collection. Note: female cones are the reproductive "berry-like" structures that contain seeds.

Scale Leaves/Twigs. Leaves are lens-shaped and overlap. Twigs are composed of whorls of 2-3 overlapping leaves that do not have denticulate margins (Adams and Murray 2004).

Wood (charcoal). The cells of juniper wood consist of tracheids with abundant, discontinuous, and visible rays. No resin canals are present. Ring boundaries are aligned in parallel rows and the latewood zone is narrow to very narrow with wide earlywood zones (Adams and Murray 2004).

Ephedraceae *(Mormon-tea Family)*

Ephedra-type (jointfir)

The ethnographic record demonstrates that *Ephedra* is an important plant used for a variety of purposes by many Native American groups. The Hopi in particular use(d) *Ephedra* for both a food and a medicine (Rainey and Adams 2004). *Ephedra viridis* grows abundantly around Sand Canyon Pueblo today (author's observation 2008, 2009).

Cone. These reproductive structures are sessile (having no branch or stalk) and are obovoid in shape and have scales. Ephedra cones attach at a node in groups of two or more. The scales may or may not be clawed and are also sessile. Based on size (2-4mm), specimens are identified as female cones but this may reflect a stage of development so caution is advised. Present in quantities in new Sand Canyon sample FV20, they are present in midden contexts also. Photographs D.12-D.14 are examples.

Stems/twigs. Ephedra stems are narrow and ridged. Similar in appearance to *Equisetum* (horsetail), they are not hollow but solid with no obvious growth ring patterns. Charred ephedra stems are highly light reflective and often the outer surface appears shredded away exposing longitudinal vessels similar in appearance to individual fibrovascular bundles. The outer surface appears prickly. Many of the stems recovered in new Sand Canyon sample FV20 also exhibited cones on the nodes. These specimens are a good seasonality indicator. *Ephedra nevadensis* forms buds in early spring with cones opening from March through May (Anderson 2004). The presence of many broken twig specimens do hint that the plant stems may have be used for tea of some kind of infusion and then discarded.

Wood (charcoal). Ephedra is a gymnosperm with vessels instead of tracheids. These are small, solitary, abundant and concentrated in the earlywood. Characteristic scalloped or wavy ring patterns distinguish ephedra on cross-section. There are no resin canals and rays are large (Adams and Murray 2004). The chemical, ephedrine, gives *Ephedra* its name and pharmacological properties. *Ephedra* would make a poor fuel wood resource and the medicinal effects of the plant indicate that the discard of its wood in thermal features is most plausibly due to the discard of unwanted parts in medicinal applications.

Pinaceae *(Pine Family)*

Pine is an important plant used extensively for a variety of purposes by many Native American groups (Rainey and Adams 2004). Uses include fuel materials, construction, ritual, medicinal and other purposes. Some groups used needles from pine species as medicine. Pinyon is recorded by Whiting (1939:23) to be used as a tinder material. A Hopi clan is named after pinyon pine suggesting the plant's importance to the Hopi in the recent past (Whiting 1939:47).

Pinus contorta-type (lodgepole pine)

Needle fragment. Pine needles have characteristic morphology that can be used to identify between species. Harlow (1931) provides cross-section detail that aid in the identification of these needle types. The information presented here is from Harlow (1931). The fascicles[148] of *P. contorta* contain two needles giving this species its half-moon shape on cross-section. They contain two medially located resin canals. On cross-section epidermal cells are square in appearance and the outer endodermis walls are thick. Two fibrovascular bundles are located in the center of the needle

[148] Fascicles are clusters or bundles that hold needles. The number of needles present in a fascicle is usually characteristic of a given species in pine (Harlow (1931:11).

separated by thin-walled tissue. Lodgepole needles are distinct from *P. edulis* needles that also are half-moon shaped, by virtue of the elongated form and additional fibrovascular bundle (Harlow 1931:Plate 12.1). Heil and O'Kane (2005:9) note the presence of *P. contorta* locally in the Sand Canyon area (Montezuma County). Typically inferred as tinder material, I assert that the needles are plausibly evidence of medicinal applications as noted in ethnographic records (Moerman 1998).

<u>*Pinus edulis*-type (pinyon pine)</u>

Bark. Bark consists of outer tree tissue, which includes the inner bark (living tissue) and the outer bark (nonliving tissue). Specimens identified to this category display typical resin canals associated with this species. Resin canals are "flower-shaped" and very distinctive.

Cone scale/umbo. These scales/umbos are ovate to triangular in face view. The apophysis[149] and umbo[150] are visible on the dorsal surface. They are approximately 1-3 cm in length. *Pinus edulis*-type umbos do not have a prickle whereas *P. ponderosa* have a very sharp prickle (Adams and Murray 2004).

Needle fragment. Pinyon pine fascicles contain two needles giving each needle its typical half-moon shape in cross-section. Usually two resin canals are present located on the thick-walled epithelial cells near the needle surface. The endodermis is uniform and thick in appearance. The hypoderm is also thick-walled and evenly striated. One fibrovascular bundle is noted in the center with strengthening cells often appearing in a line above and below the bundles (Harlow 1931:Plate 4.4). Photograph D.15 and D.16 (Appendix D) show some needle fragments recovered from the new Sand Canyon Pueblo samples.

Wood (charcoal). The cells of pinyon pine consist of tracheids with abundant continuous and discontinuous rays. On microscopic cross-section, ring patterns are variable but have a thin latewood zone. Small, abundant resin canals with distinctive surrounding epithelial cells (the "flower"-shape noted on the previous page) are present and distributed throughout the ring. Because of the abundance and characteristic shape of resin canals in this species it is possible to easily distinguish it from other pine species even when specimens are small.

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[149] An apophysis is the part of a cone-scale that remains exposed when the cone is closed (Hickey and King 2000:3).

[150] Umbos are exposed protruberances on cone scales (Hickey and King 2000:4). In certain species these are quite distinctive. Ponderosa umbos are large and have a sharp point.

<u>*Pinus ponderosa*-type (western yellow pine)</u>

Needle fragment. Two and three needles per fascicle are characteristic of *P. ponderosa* with two medial resin canals surrounded by thick-walled cells. The outer endodermis walls are thickened and two distinct fibrovascular bundles are located in the center of the needle (Harlow 1931:Plate 13.1). Dunk (2006:61) notes that *P. ponderosa* is found to the east of the Sand Canyon Locality. Photograph D.17 shows the distinctive triangular cross-section morphology of this needle type (modern comparative specimens), notable for three obvious resin canals. Harlow notes 3-10 resin canals can be present in this pine species although two is most common.

<u>*Pinus*-type (pine)</u>

Bark. Specimens identified to this category display the outer nonliving tissue of pine and resin canals are large without evidence of obvious epithelial cells.

Bark scale. Oval/elliptic to ovate in face view and lens-shaped in cross-section. Bark scales are thick in the center and thin towards the rim. Adams and Murray (2004) record that the shape resembles puzzle pieces usually 1 cm or less in length. Surface is generally smooth but the dorsal surface may have small holes.

Wood (charcoal). Pine morphology consists of tracheids with abundant continuous and discontinuous visible rays. The growth ring boundaries are distinct but vary in size from growth ring to growth ring. The boundaries are thicker in the latewood zone and resin canals are more concentrated in the latewood (Adams and Murray 2004). *Pinus* resin canals are large and lack the abundant surrounding epithelial cells so typical of *Pinus edulis*. Wood identified to *Pinus*-type may be *P. ponderosa* or may be too degraded to positively identify to *P. edulis*-type.

Wild plants: Angiospermae

Angiosperms

<u>Angiosperm, unknown</u>

Flowering head. Measuring between 2 and 7.5 mm in length and averaging approximately 1.5 mm in width and thickness, these flowering heads have multiple rounded bud-like structures. The overall shape of the stalk is straight with buds placed alternately like pistillate flowers. *Artemisia tridentata*-type flowering heads are ruled out because there is no narrowing at the base of the stalk or a flaring out at the apex typical of the calvate shape of *Artemisia*. There are also no denticulate surfaces to suggest that these specimens could be *Juniperus osteosperma*-type developing cones. Photograph D.140 is an example.

Pith. Pith is the central soft tissue of a stem (Benson 1959:660). Specimens identified in this category are too ambiguous to identify further and are inferred to represent this designation.

Twig. Specimens identified as a specific type of twig show the ring patterning typical of wood. Often they do show the characteristic morphology of particular wood types on cross-section.

Wood (charcoal), diffuse porous-type. A dicotyledon (hardwood) classification based on pore size and distribution within a growth ring viewed in cross-section (Hoadley 1990:32). Diffuse-porous wood can have a range of vessel sizes but tend toward solitary vessels of various sizes scattered throughout the growth ring. Examples of diffuse-porous woods are: mountain mahogany (*Cercocarpus* sp.), fendlerbush (*Fendlera* sp.), and wolfberry (*Lycium* sp.)(Adams and Murray 2004). Identification to this category is based on size and degree of degradation that precludes a more specific taxonomic designation.

Wood (charcoal), ring porous-type. This is a category of charred wood. Vessels are present that are clearly larger in the earlywood and smaller in the latewood with an abrupt transition between them. The wood has an obvious "ring" of vessels inside the boundary between growth rings, often visible to the naked eye (Adams and Murray 2004). Examples of ring-porous type woods include: oak (*Quercus* sp.) and lemonberry/sumac (*Rhus* sp.)

Wood (charcoal), semi-ring porous-type. This is a category that describes the vessel pattern of an unknown wood. The vessels are present and graded in size being much larger in the earlywood and smaller in the latewood. There are no resin canals. Rays are visible and varied (Adams and Murray 2004). Examples of semi-ring porous wood include: chokecherry/rose-types (*Prunus* and *Rosa* types), cliff-rose/bitterbrush (*Purshia*-types).

Wood (charcoal), unknown type. On cross-section these specimens have vessels but the patterning is too indistinct, degraded, or fragmentary to identify further. Growth ring patterns are not discernible.

Wood (charcoal), unknown type with lenticular surface. On cross-section these specimens have vessels but the patterning is too indistinct, degraded, or fragmentary to identify further. However, they are distinctive in that surfaces are pitted with lens-shaped holes such as those found on *Artemisia* and *Chrysothamnus* (photographs D.147-D.150).

Wild Plants: Monocotyledonea

Monocotyledons

<u>Monocotyledon (monocot), unknown</u>

Fibrovascular bundle. Fibrovascular bundles (FVBs) are cylindrical, narrow, and rigid and are oriented longitudinally and evenly. They are very fine in diameter and are composed of 30 or more individual fibers and associated tissue and are found in stems and leaves. Aligned parallel to each other they show up circular to elliptic in shape in cross-section under the microscope. Width is approximately 0.2-0.4 mm.

Leaf. The leaves of monocots are rectangular in face view and in cross section, and display parallel venation due to fibrovascular bundles oriented longitudinally and evenly throughout. Leaves may be thin (as in *Zea* or other grasses) or thick (as in *Yucca*). FVB are very light reflective when charred.

Stem. Stems are long, narrow, and circular on cross-section. Surface is smooth with longitudinal striations or ridges and usually hollow but sometimes solid. Monocots have fibrovascular bundles visible in the background tissue. Sometimes long internodes and shorter nodes where the leaves once attached can be seen. May be very narrow (as in wild grasses), or wide (as in *Yucca* and *Zea mays*).

Tissue. Specimens identified as monocot "tissue" are variable in size and shape but characterized by highly light-reflective fibrovascular bundles distributed throughout. Often the bundles are broken or ripped at different lengths and detached from the background tissue. Photographs D.26-D.28 (Appendix D) are examples.

Agavaceae *(Agave/Century-Plant Family)*

<u>*Yucca baccata*-type (Datil/banana yucca)</u>

Rainey and Adams (2004) record multiple uses of numerous species of *Yucca* by Native American groups for food and other purposes such as soap. Other species are recorded were also used for medicine and ritual (Moerman 1998). Datil yucca is found in abundance at the site today.

Fibers. (See also Monocotyledon fibrovascular bundles). Specimens identified to this category are hair-like and circular to elliptical in cross-section. All specimens are charred and twisted together.

Leaf. Yucca leaves are triangular in face view and widest at the base narrowing toward a pointed and sharp tip (Adams and Murray 2004). The leaves have visible fibrovascular bundles and smooth leaf margins. Specimens identified as Datil yucca leaves are fragmented and compare well to comparative material.

Stem fragment/stalk segment. Specimens are circular in cross-section with fibrovascular bundles scattered throughout comparing well to uncharred comparative specimens.

<u>*Yucca*-type (yucca)</u>

Capsule/pod. A single specimen is uncharred and either loculicidal (where the seed is contained in a cavity) or septicidal (where the seed is contained in a partition of the cavity)(Harris and Harris 1994: 201-206). The pod measures 5 cm in length by 3 cm in diameter appearing immature. When compared with drawings from W.T. (1892) it does not compare well to *Y. baccata*.

Leaf. Specimens identified to this category were too fragmented to classify as *Y. baccata*.

Cyperaceae *(Sedge Family)*

<u>*Eleocharis*-type (spikerush)</u>

Eleocharis is a new taxon for Sand Canyon Pueblo and rarely recovered in archaeological sites. This could be due to the minute size of the achenes that typically fall into the .25 mm size range. An uncommon abundance of these remains was identified. The remains recovered were broken displaying characteristic morphology of thickened achenes with distinctive horizontal striations. Spikerush grows in marshes (fresh and saline), ephemeral ponds, flooded playas, ditches, intermittent streams, and other aquatic environments. Spikerush plants do not produce fruit until 2-3 years of age and achenes typically germinate in standing water mid-spring through early summer. The plant is drought intolerant (Hauser 2005). Stems of spikerush are available any time between April and October in that part of the Four Corners. Heil and O'Kane (2005:36) observed several varieties of *Eleocharis* in Colorado, particularly in the LaPlata and San Juan Counties. *E. acicularis* has been noted in Dolores County, located in close proximity to Sand Canyon. Adams (1988:215-216) documents *E. rostellata* mature fruits present at Canelo Hills, Cienega, southern Arizona in September.

Eleocharis has an interesting archaeological and ethnographic record. Adams (1988) notes that *Eleocharis* cf. *utahensis* achenes were eaten at Lovelock Cave in Nevada at some time over a 2000-year period (1000 B.C. – A.D. 1000). An *Eleocharis montana*-type achene was excavated from Salmon Ruin in northwestern New Mexico from A.D. 1090-1130. Vestal (1952 in Adams 1988:215) records that *E. rostellata* was used by the Ramah Navajo of New Mexico as a Holyway[151] emetic. *E. palustris* is also recorded as used for ceremonial and medicinal emetics by the Navajo (Wyman and Harris [1941] in Adams 1988:215). Some of the Northern Paiute used *Eleocharis* stems in weaving (Stewart [1941] in Adams 1988).

I originally categorized Cyperaceae stem segments from sample SC9 as "stem type E" (presumably a grass type). Found in association with *Eleocharis* achenes in the Sand Canyon Pueblo samples, I think are most plausibly spikerush stems.

Achenes and seeds. Spikerush achenes are triangular or ovate-lens-shaped. Minute in size and observed in the .71- to .25-mm screens, the outer surface is thick and smooth with distinctive cellular reticulations (finely etched horizontal ridges running between parallel veins particularly evident on the inner and outer surface of the seed coat)(Martin and Barkley 1961:136, USDA NRCS 2009). Identification of this taxon was made based on charred comparative materials (*E.acicularis, E. palustris*, *E. rostellata*, and *E. wolfii*). The achenes were recovered charred in various forms. Some specimens were broken and displayed characteristic thick walls, other specimens were seeds. The inner seed is light-reflective, smooth, showing slight reticulations and triangular in face view and compressed on cross-section. Photographs D.18 to D.21 (Appendix D) are examples.

Scirpus-type (bulrush)

Achenes and seeds. These small specimens are approximately 1 mm in width and 1.5 mm in length. Many appear swollen and rounded with charring. They are ovate in face view with a pointed end. Some have even longitudinal depressions (photographs D.22, Appendix D).

Juncaceae *(Rush Family)*

Juncus-type (rush)

Heil and O'Kane (2005:43-44) note numerous *Juncus* varieties in southern Colorado. There are 36 varieties of *Juncus* native to Colorado (USDA NRCS 2009). The seeds of some species are minute in size and, if present, might be recovered in the smallest light fraction screen sizes. Rainey and Adams

[151] Holyway is one of four Navajo ceremonials. The Holyway ceremony is used for cures or preventatives (Goodwin 1945:499).

(2004) record the use of *Juncus* (*J. balticus and J. torreyi*) by the Hopi occasionally in ceremonies. A few other Native American groups also used the plant although details are lacking.

Achene/seed. Identifications of the seeds as *Juncus* are tentative. The specimen recovered in FV10 is degraded but shows the globose/elliptical shape and typical pointed ends (the apex in particular) of *Juncus* sp. Surface reticulations are not present and likely burned away due to charring. There is a rounded portion of the mid-section of the seed that is missing, possibly eaten away. This specimen measures approximately .75 mm by .25 mm. Thickness is estimated to be approximately .25 mm. The specimens were compared with the CCAC Herbarium Collection (#482 *Juncus balticus* Willd.), herbarium specimens from Agri-Food Canada, Kamloops, B.C., and the University of Victoria Herbarium Collections. Photograph D.23 (Appendix D) is an example.

Poaceae *(Grass Family)*

> The people were sad, they were hungry and talked loudly. *Pyüükoñhoya and Paluñhoya*, the twins, sons of the Sun, creator of clouds (Stephen 1929:12), felt saddened and taking their bows and arrows went north… Pulling out their hairs, they cast them to the winds, calling each handful by the name of something growing out of the ground, as pine, piñon, cedar, oak, the grasses… "When people should become thirsty and want water to use in quantity, they should pull up grass and in place of the roots water will come," they counseled. "When people use what water they need, the grass should be put back in its place so that it will continue to grow and preserve the water."
>
> adapted from Alexander M. Stephen's *Hopi Tales*, as told by Pauwatiwa of the Reed clan, Chief of the Warrior's society. This tradition is told during the war ceremony in December (Stephen 1929:50-51).

Doebley (1984:62) notes that grasses, particularly *Stipa/Oryzopsis hymenoides*, played an important role in subsistence in the American Southwest, *Oryzopsis* being the single most valuable wild cereal. The ethnobotanical literature details that wild grasses were cultivated and may have been irrigated in planted fields (62). Minnis (1989) reports the use of several grass types as both food and medicine.

Bromus-type (brome)(Pooideae)

A member of the subfamily, Pooideae, *Bromus* L. is estimated to include 100-400 species, 28 are native to Colorado. Many are weedy and grow in disturbed sites (Pavlik and Anderton 2016). Doebley (1984:54) notes that *Bromus catharticus* Vahl., an introduced species, was used formerly by the Paiute. Brome is a new identification for Sand Canyon Pueblo.

Caryopsis. The embryo in the single specimen recovered is small in proportion to size of the caryopsis. The endosperm is large matching the typical panicoid pattern (Reeder 1957:758). The grain is tightly enclosed and narrowly ellipsoid (photograph D.29, Appendix D).

Stipa comata (needle-and-thread grass)(Welsh et al. 1987:782); *Hesperostipa comata* (Zlatnik 1999:1)

Needle-and-thread grass is a cool-season, native, perennial bunchgrass that is moderately to highly drought resistant (Zlatnik 1999:9). In Utah, it flowers in early June and sheds ripe seeds in July (11). The Hopi are known to use *Stipa neomexicana* (Needlegrass) plant to make necklaces for ceremonial purposes (Rainey and Adams 2004; Moerman 1998:545). No record of use as a food is noted. This is a new identification for Sand Canyon Pueblo. To make a confident identification I charred needle-and-thread grass for comparison and found the awns compared very well in size and morphology.

Awn. Awns are the twisted terminal bristle found at the apex of the spikelet (Gould 1981 [1951]:247-249). The specimens recovered were charred awn segments partially untwisted and compared favourably to the author's charred comparative collection. In non-charred form the twists are tightly molded together. Photographs D.32-D.34 show the specimens recovered.

Stipa hymenoides [Oryzopsis hymenoides](Welsh et al. 1987:783); *Achnatherum hymenoides* (Roemer & J.A. Schultes) Barkworth (USDA NRS 2009; Tirmenstein 1999)(Indian ricegrass)

The common name, "Indian ricegrass," is also applied to *Ericoma membranacea* (Pursh) Beal., *Stipa hymenoides* Roem. & Schult., *Eriocoma cuspidata* Nutt., *Achnatherum hymenoides* (Roem. & Schult.) Barkworth, and *Oryzopsis hymenoides* (Roem. & Schult.) Ricker ex Piper (USDA NRCS 2014).

Tirmenstein (1999) records that *Achnatherum hymenoides* naturally spreads aggressively from seed. Seed development is adversely affected if spring rainfall (typically in April) is low. This species dominates sandy soils in arid and semiarid sagebrush-grasslands such as those that occur prolifically around Sand Canyon. Seeds are noted to ripen in July (Tirmenstein 1999). Adams (1993b:208) notes that Indian ricegrass ripens in the area in mid-June. Doebley (1984:56) records the flowering of Indian ricegrass from June to August. The seeds (caryopses) of Indian ricegrass were/are used by many Native American groups. Whiting (1939:47) records a Hopi clan as named after Indian ricegrass reinforcing the ideational significance of the plant to the Hopi in the recent past. The Hopi are known to grind Indian ricegrass for meal, breads (tortillas) and cakes as well as using this species as a “starvation” food (Rainey and Adams 2004; Moerman 1998). Stevenson (1915:67) quotes Palmer (1871:419):

> *Ericoma cuspidata* [Indian ricegrass]. This is a singular species of grass, which is found growing wild in moist sandy spots in Nevada, Arizona, and New Mexico, and produces a small, black, nutritious seed, which is ground into flour and made into bread. It is held in high estimation by the Zuñi Indians of New Mexico, who, when their farm crops fail, become wandering hunters after the seeds of this grass, which is abundant in their country. Parties are sometimes seen ten miles from their villages, on foot, carrying enormous loads for winter provision.

Caryopsis. These are globose and ovate in face view and circular in cross-section, bulbous at the distal end and tapered at the proximal end (Adams and Murray 2004). This species has a relatively large and embryo. The specimens measure approximately 1.25-1.75 mm (photograph D.35, Appendix D).

Floret.[152] Globose in shape and oval in face view, this grass floret has a bulbous base and pointed apex with the palea and lemma still attached. Typically, these florets are slightly over 2 mm in length and 1 mm in width it often has a smooth surface texture (Adams and Murray 2004). The specimens identified here compare well with charred comparative material collected at the site in June 2008.

<u>Poaceae, festucoid-type</u>

Caryopsis. Dorsal embryo depression is relatively small in comparison with the total endosperm comparing well to a true festucoid grass (Reeder, 1957). This caryopsis has three nerves (or ridges) running the length of the grain clearly seen on the ventral side (photograph B.33-B.35). There is no evidence of palea or lemma and it is possible that this caryopsis is one of a type of genera that separate easily from these structures (Gould and Shaw 1983:65).

<u>Poaceae, panicoid-type</u>

Caryopsis. The caryopsis is minute measuring .5 mm in length by .2 mm in width. The diameter is estimated to be approximately .2 mm. The embryo depression appears to be between one-quarter to one-half the size of the endosperm suggestive of a panicoid-type (Reeder 1957).

[152] The term floret can be defined as simply a flower but when used to describe a grass flower, the lemma and palea are included. The palea and lemma are modified leaves or “bracts or glumes” that enclose the floret. The palea is inner bract, the lemma is the outer bract (Harrington 1977:117, 131).

Poaceae, unknown-type

Floret. A variety of Poaceae florets are present in the SCP samples, many are charred. Without clear evidence of the embryo depression, it is not possible to suggest a type (panicoid, festucoid).

Stem, uncategorized/unknown. Block 1200 Midden (FV14) yielded such a large quantity of what appeared to be grass stem fragments with clearly different surface textures that a tentative classification of stem types seems appropriate. Five categories are described below. Other Poaceae stems were present but too degraded or fragmented to describe. The identification as "Poaceae" may need further analysis. An additional "stem type E" originally designated as a grass is thought to be rush or sedge and categorized as Cyperaceae-type.

Poaceae (type A) stem. Minute hollow stem measuring less than 1 mm in diameter, slightly compressed. Highly light reflective surface with minute flecks oriented longitudinally. All specimens show evidence of "bend" marks oriented horizontally. Epidermal tissue is glabrous (probably not as a result of charring) and lustrous (photographs D.36 and D.37).

Poaceae (type B) stem. This sturdy grass stem has a .5 to slightly over 1 mm diameter and parallel striations running lengthwise. The stem is hollow and hard to break or crush. The outer epidermal layer is very fine and in some areas has burned away to show a more light-reflective inner surface. Generally the outer epidermis is glabrous which could be a normal characteristic or as a result of burning. On cross-section, fibrovascular bundles can be seen because of their light reflectivenature and the overall thickness of the stem's internal structure. Type B is the sturdiest and thickest internally of all the unknown stems (photographs D.38-D.40).

Poaceae (type C) stem**.** Type C is similar to type B in surface characteristics. Fine parallel striations run the length of the stem but whereas type B is not easily broken with handling, type C is papery and easily crushed. The stem is hollow but is present as either compressed, forming an oval in cross-section, or round. Fibrovascular bundles can be seen very faintly due to the minute size of the stem. The diameter of the stem is approximately 1 mm. Type C, like type B is light reflective but not overly so. The specimens lack the highly light reflective quality of type A and show no evidence of bend marks. These differ from the other Poaceae stem categories by its somewhat plain surface texture, compressed stem and hollow, ovoid-shaped interior. On cross-section it is difficult to discern fibrovascular bundles (photographs D.41-D.43).

Poaceae (type D) stem. These 1-mm wide stem fragments are hollow with a rigid surface layer that snaps cleanly. All surfaces are highly light reflective and the outer surface is covered in flecks oriented longitudinally. No nodes are visible in any of the samples. Fibrovascular bundles can be seen on cross-section (photographs D.44 and D.45).

Wild plants: Dicotyledonae

Dicotyledons

Dicotyledon, unknown

Leaf. Dicotyledon leaves have principal veins that branch out from a midrib or from the base of the leaf. These veins form a distinct network based on the species (Benson 1959:88).

Amaranthaceae *(Amaranth Family)*

Amaranthus-type (pigweed)

This species has a weedy habit and is prolific in gardens and agricultural fields. The plants are widely used by many Native American groups for food, medicine, ceremonial, and other purposes. The Hopi cultivated pigweed in the recent past and the flowers are used to color piki bread red (Rainey and Adams 2004; Moerman 1998:65).

Seed. Seeds are circular-lenticular in face view with a narrowed edge forming a thin rim and an encircling embryo. Approximately 1-1.5 mm in diameter, they are naturally shiny black in colour. Specimens identified to this genus show marked rims that differ from specimens identified to *Chenopodium* (photographs D.46 and D.47). Martin and Barkley (1961:153) note that *Chenopodium* (goosefoot) has a rounded edge with a notched margin that is often not obvious.

Asteraceae *(Aster/Sunflower Family)*

Artemisia-type (sagebrush)

A variety of sagebrush species were used by Native American groups (Moerman 1998). The Hopi specifically use(d) big sagebrush (*Artemisia tridentata*) as fuel, food (leaves), medicine (infusion using leaves), and for ceremonial purposes. The wood is part of the flute *paho* (prayer stick)(Whiting 1939). Other Southwest groups use the achenes as food (Rainey and Adams 2004). Scott and Aasen (1985) note the use of sagebrush achenes to make “mush.”

Wood (charcoal). See *Artemisia tridentata*-type. Remains identified to *Artemisia*-type are generally more degraded or fragmented and therefore identification to *A. tridentata* is not made.

Artemisia/Cercocarpus-type (sagebrush/mountain mahogany)

Wood (charcoal). See also Cercocarpus (Rosaceae Family). This dual category reflects wood specimens displaying a diffuse porous ring pattern with widely spaced solitary vessels of variable size. The rays are abundant, thin, continuous and discontinuous for this category. Ring boundaries are indistinct but marked with widely spaced earlywood vessels (Adams and Murray 2004). Identified to this compound type because the specimen does not compare favourably enough to *Cercocarpus* or *Artemisia* to distinguish between them.

Artemisia tridentata-type (big sagebrush)

Achene. Big sagebrush achenes are small and clavate-shaped in face view. In cross-section, they appear circular or oval. They are often found in pairs with ancillary parts attached at the base, and measure approximately 1.5 mm in length with a generally smooth surface (Adams and Murray 2004). Specimens identified to this species compare very well with comparative *Artemisia*-type achenes from New Mexico (Trisha Rude 2008 comparative collection). Sand Canyon Pueblo achenes are shown in photograph D.48 to D.50 (Appendix D).

Wood (charcoal). The vessels characteristic of big sagebrush are small, solitary, clustered, abundant and distributed within the ring in flame like patterns with vessels concentrated at the earlywood and latewood boundaries. Ring patterns are semi-ring porous with distinct ring boundaries with a band of cork tissue evident (Adams and Murray 2004). Breakage along this band is common. This weakness in ring structure may explain the fragmentary nature of the species when charred and as a result specimens may be very small in size. The vessel patterning is so distinctive that even very minute pieces can be distinguished as sagebrush. The rays are abundant, wide, distinct and continuous. On tangential view, lenticular pores are visible and similar to *Chrysothamnus* (see *Chrysothamnus* for identification on cross-section view). My charring tests show that this species easily breaks along the cork rich rings when burned as a fuel.

Flowering head. These small specimens are clavate (tear-drop) in shape and are similar to a flower bud with a series of overlapping bracts attached at the base of the cluster (Adams and Murray 2004). When broken, one or two achenes can be seen (pairs of achenes are often seen). They have the general appearance of a papery bud, approximately 2 mm in length. Photographs D.48 and D. 49 (Appendix D) are specimens from the 2009 Sand Canyon analysis.

Immature flowers. These specimens are flowering heads preserved earlier in the reproductive sequence with the typical clavate (tear drop) shape. The lack overlapping bracts and less well defined than more mature flowers.

Leaf and leaf fragment. These specimens are ovate in face view with a narrow base and three slightly incised lobes at the apex. Thin in cross-section and approximately 3 to 12 mm in length, 1.5 to 5 mm in width. The lobes are smooth and flat, lacking the leaf-tip prickles and rolled edges of *Purshia*-type (Adams and Murray 2004) making them distinguishable from that genera. Identification was confirmed with both charred and uncharred modern comparative material (photograph D.57, Appendix D).

Chrysothamnus-type (rabbitbrush)

Many Native American groups use parts of rabbitbrush for a variety of purposes. The Hopi use the bark, wood, and other parts in religious ceremony. The flowers are used for dye, and the wood and stems for construction and fuel (Rainey and Adams 2004). *Chrysothamnus* is one of the four ceremonial kiva fuels for historic Hopi (Hough 1897). Whiting (1939:22, 23, 47) notes rabbitbrush as a Hopi clan name suggesting the plant's importance in the recent past. See *Chrysothamnus*-type for identification criteria. Specimens identified to *Chrysothamnus*-type are likely to be *Chrysothamnus nauseosus*/*Ericameria nauseosus* (rubber rabbitbrush) that dominates the area around Sand Canyon today. Identifications to this type may well be reasonable for the rabbitbrush remains identified in the 2009 analysis, but I chose to err on the side of caution and identified only to *Chrysothamnus* sp.

Wood (charcoal). The vessels are circular to nearly rectangular and graded larger in the earlywood and smaller in the latewood. The rays are abundant, distinct, wide, continuous, and discontinuous. Adams and Murray (2004) describe the wood on cross-section as displaying a thumbprint pattern created by horizontal wavy groups of vessels and highly light-reflective background cells. Ring boundaries are indistinct and only visible at higher magnifications. Rabbitbrush is very similar to *Artemisia* but does not display the flame-like patterning of vessels and cork tissue diagnostic of sagebrush. Lenticular pores on the bark can be seen. Unlike the typical lenticular bark of *Artemisia tridentata*, *Chrysothamnus* lenticels have internal nodules (photographs D.147-D.150, Appendix D). Because of the breakage associated with the ring boundaries it is possible that this wood type also fractures easily during burning which may explain its relative absence in thermal features.

Brassicaceae *(Mustard Family)*

Descurainia (tansy mustard)

A number of Native American groups used *Descurainia* (tansy mustard) for various purposes. The Hopi are documented to use the plant for food generally, and eaten as greens specifically. They have also used it for pottery paint. Other groups utilize the seeds, roasted and parched as food (Rainey and Adams 2004). Moerman (1995: 198) records the use of *Descurainia Sophia* (L.) Webb ex Prantl (herb Sophia) as a stored winter food, and for soups or stews. Whiting (1939:47) notes the Hopi use of the name tansy mustard (in this case, *Sophia pinnata*) as a clan name, which suggests cultural significance beyond merely a useful food plant.

Seed. The seeds are less than 1-mm in length and are oblong-oval and compressed. The surface is finely reticulate lengthwise (Martin and Barkley 1961:163). A marked groove runs the length of seed marking the recumbent embryo. See also *Sisymbrium/Thelypodiopsis* (hedgemustard/tumblemustard) recorded under Unknowns, botanical materials.

Cactaceae *(Cactus Family)*

Opuntia (prickly pear) cactus

All parts of the plant are documented as food and medicine by Native Americans (Rainey and Adams 2004). Some parts are used as tools or to make dye with the gathering of seed typically occurring in September. Whiting (1939:47) records the name for *Opuntia* (various species) as clan names suggesting the plants' cultural significance to the Hopi in the historic past. Harvesting prickly pear cactus seeds is difficult due to the sharp spines although cactus-picking tweezers are recorded (Cushing 1920). Often inferred as non-preferred, less desirable, or "famine" foods, Cushing's (1920) descriptions of dances associated with *Opuntia* and *tchamahia*, the "stone hoes" of ancient people attest to its importance in enactments of war. The opposite may be true, that the difficulty in collection make these plants more desirable.

Embryo. The seed embryos are circular, "comma"-shaped, very curved and smooth with the two ends almost touching. Embryos measure approximately 2.8-3 mm and easily detach from the seed.
Seed. Seeds are flat and sub circular, characterized by a distinct groove running parallel to the margin, measuring 3-5 mm across (Martin and Barkley 1961:184). A distinct marginal rim is also evidence and placed lower in relation to the raised center of the seed that contains the embryo (Adams and Murray 2004).

Capparaceae *(Caper Family)*

Polanisia-type (clammyweed)

Moerman (1998:421) records that Pueblo groups used *Polanisia dodecandra* ssp. *trachysperma* (Torr. & Gray) Iltis (sandyseed clammyweed) as dried food for winter use. The plant was also cooked in soups and stews and used as greens. The plant is also notable as a feature of ceremony and the making of ceremonial items. Stevenson (1915:96) records the Zuni names, *A'pitalu*, "hands many seeds" as the name given to both *Polanisia trachysperma* Torr. & Gray. and *Cleome serrulata* (Rocky Mountain Bee Plant). In the case of *Polanisia*, the plant was associated with the Cactus fraternity. From the Capparaceae family notable for its pharmacology, the plant may be associated with medicine (see chapter eleven).

Seed coat. This specimen is a fragment and exhibits the typical compressed-globose shape of this genus and the finely reticulate surface patterning that curves in lines along the length of the outer surface.

Caryophyllaceae *(Pink Family)*

Vaccaria/*Vaccaria hispanica* (Mill.) Rauschert (soapwort, cow soapwort, cowherb, cowcockle)

Seed coat. This seed coat appears to be charred, almost whole, rounded with slight compression on one side measuring approximately 1-mm in diameter. The surface is papillose (dimpled) evenly and distinctively. The specimen was compared with *Saponaria* species at the University of Victoria Herbarium and found to be a poor match. The most favourable comparison for size, shape and surface patterning is with *Vaccaria hispanica* (see USDA NRS 2015 for an excellent comparative photograph). Flora of North American [online] report that *Vaccaria* was once a common weed plant in grain fields and has become increasingly rare. In some localities the plant has been extirpated. The seeds contain saponin that toxic to ingest (eFloras.org). Heil and O'Kane (2005:31) note the presence of *Vaccaria pyramidata* Med., in Archuleta County around Pagosa Springs, southwestern Colorado. Photographs D.51-D.53 (Appendix D) show the specimen encountered in a Sand Canyon sample in 2009. This species is designated as a Eurasian introduction (USDA NRCS 2015).

Chenopodiaceae *(Goosefoot Family)*

Atriplex or *Atriplex canescens*-type (saltbush or four-wing saltbush)

Atriplex canescens is present in abundance at Sand Canyon Pueblo today (observed 2009 by this author). In the interests of taking the conservative view, specimens are identified simply to *Atriplex* and presumed to be *canescens*-type. Many Native American groups used four-wing saltbush for a variety of purposes, food, spice, medicines, and forage (Moerman 1998:115). Specifically, the Hopi made use of four-wing saltbush as food for greens and the ashes to color piki bread (Whiting 1939). *Atriplex canescens* is one of the four ceremonial kiva fuels and the wood is used to make prayer sticks (Rainey and Adams 2004).

Bract fragment. This nearly complete fragment is similar to Four-wing Saltbush fruit bracts. Papery and possibly charred (or at minimum embedded with ash), this tiny bract was found in association with a charred *Atriplex* seed.

Seed. The seed is approximately 1.5 mm in diameter. It is circular in face view and flat in cross-section with a ringlike embryo clearly evident on the exterior margin protruding at the radicle (Martin and Barkley 1961:52). The seed was compared with herbarium specimens from the University of Victoria Herbarium collection and found to be a good match for size, shape and surface structure. Photograph D.55 to D.56 (Appendix D).

Atriplex-type (saltbush)

Wood (charcoal). Vessels in saltbush wood share walls making individual vessels difficult to distinguish. They are most obvious in the earlywood. Ring patterns are ring porous in wavy or ripple patterns. Rays are not visible and ring boundaries are difficult to discern. This wood type can be confused with *Ceratoides lanata* (winterfat)(Adams and Murray 2004).

Cheno-am (*Amaranthus/Chenopodium*-type)

Seed/seed coat/immature interior. See *Amaranthus*-type or *Chenopodium*-type for descriptions. Specimens identified to cheno-am-type are indistinguishable between the two genera. Specimens identified as “immature interior” reflect an immature stage of development.

Chenopodium (goosefoot) (see also *Amaranthus*-type and cheno-am-type)

Goosefoot has a weedy growth habit and grows prolifically in disturbed areas such as gardens and agricultural plots. An important plant used by many Native American groups, the Hopi specifically used goosefoot as food, using the leaves, flowers, and seeds in a variety of ways. The leaves are eaten when they are young, some gathered in the spring (Rainey and Adams 2004).

Seed. Seeds are circular-lenticular in face view and approximately 1-2 mm in diameter. Specimens identified to this genus have a rounded margin without an obvious rim. Naturally shiny and black, specimens were broken to ensure they were charred (photograph D.55, Appendix D).

Ceratoides lanata-type/*Krascheninnikovia lanata*-type (winterfat)

Twig. The vessels in this wood type are solitary in scalloped or ripple patterns. Ring boundaries are indistinct. In the latewood vessels are larger and often form crescent shapes. The wood can be confused with *Atriplex*. *Ceratoides lanata* tends to break easily along the scalloped ring boundaries. Specimens identified to this taxon are found maintaining a consistent form: approximately 1-2 mm in length, one ring boundary present with a large pith area and one set of crescent-shaped vessels. Charred specimens compare favourably to uncharred comparative specimens (Adams and Adams 1987). They do not compare well with *Atriplex* specimens.

Fagaceae *(Beech Family)*

Quercus (oak)

Quercus gambelii (Gambel oak) is present in abundance at Sand Canyon near the pueblo and densely packed in the canyon below (observed 2008, 2009). Taking the conservative view, specimens identified in 2009 are recorded simply as *Quercus* but likely represent *Q. gambelii*. Many Native American groups used the species in the past (Moerman 1998). The Hopi made use of Gambel oak wood to fashion tools such as digging sticks, bows, arrows, handles and the like (Rainey and Adams 2004). Moerman (1998:461) records Hopi use of this plant in the *Oaquol* (a women's) ceremony. Whiting (1939:47) documents a Hopi clan named for *Quercus* suggesting the plant's cultural importance to the Hopi in the recent past.

Wood (charcoal). Vessels of Gambel oak are solitary, paired, or found in multiples scattered throughout the ring, larger in the earlywood and smaller in the latewood. This species is distinctive because of its occluded vessels are common and occasionally occur in flame-like groupings and are highly light reflective when charred and viewed under the microscope. Two kinds of rays are abundant: wide rays found except near the pith and thin rays between them (Adams and Murray 2004).

Hydrangiaceae *(Hydrangea Family)*

Fendlera-type (fendlerbush)

Heil and O'Kane (2005:42) note the presence of only *Fendlera rupicola* in Montezuma County near Sand Canyon. Ethnographically, fendlerbush is recorded as used by only a few southwestern Native Americans (Moerman 1998). The Hopi are documented as using fendlerbush wood in religious ceremonies, particularly ceremonies associated with the Sand Clan (Rainey and Adams 2004).

Wood (charcoal). Fendlerbush vessels are small, solitary and scattered throughout the ring. The ring patterns are diffuse porous with indistinct ring boundaries and no patterning to background cells. Rays are also indistinct, thin, continuous and discontinuous (Adams and Murray 2004). Specimens identified to this taxon are identified based on a good match to the CCAC comparative collection (Adams and Adams 1987).

Loasaceae *(Loasa Family)*

Mentzelia-type (blazingstar/stickleaf)

Used by a few Native American groups in the Southwest, *Mentzelia albicaulis* (stickleaf) seeds are documented by the Hopi as a source of food and medicine and processing of the seeds includes crushing, parching, and grinding. Seeds are also eaten whole (Rainey and Adams 2004).

Seed. Martin and Barkley (1961:183) note that blazingstar is diverse in shape. Specimens identified to this genus are 3-sided and truncate with grooves and minute, papillae-like protuberances covering the surface. The specimens identified as blazingstar/stickleaf in 2009 are not charred.

Malvaceae *(Mallow Family)*

Sphaeralcea-type (globemallow)

Many Native American groups used *Sphaeralcea*. The Hopi are recorded as using the roots and stems of globemallow as medicine and for other purposes (Rainey and Adams 2004).

Seed. Globemallow seeds are compressed-reniform in shape with one end narrowed and a deep, broad notch at the hilum (attachment point)(Martin and Barkley 1961:183). The specimen identified is 3-mm in length. It is uncharred.

Polygonaceae *(Buckwheat Family)*

Polygonum-type (bindweed/knotweed)

Used by many Native American Groups, bindweed/knotweed is documented as a food and medicine source by the Hopi (Rainey and Adams 2004).

Achene. The achenes are oval to ovate in face view and triangular in cross-section (Adams and Murray 2004). Surfaces are smooth and the sides are rounded with a slight flare. The specimen is charred and completely flat on one side.

Portulacaceae *(Purslane Family)*

Portulaca retusa-type/*Portulaca oleracea* (purslane/little hogweed)

Widely used by Native American groups, purslane is documented as a plant used for its greens (Rainey and Adams 2004). Dunmire and Tierney (1995:179) record purslane as "one of the most important wild food plants of Puebloan ancestors for at least a thousand years." In contemporary usage the stems and leaves are prepared in a variety of ways and include drying and storing for winter (179). Weedy in habit, the seeds are minute and very distinctive in shape and surface structure. Fewkes (1896:15) translates the Hopi name for purslane as, "caterpillar, his corn" (see footnote 87, page 256).

Seed. The seeds are compressed and approximately 0.5-mm across. In face view they are circular to ovate and lens-shaped in cross-section. The surface is covered by minute rounded tubercles (bumps) arranged in concentric rows (Adams and Murray 2004). These seeds are typically recovered in the smallest particle sizes of the light fraction.

Rosaceae *(Rose Family)*

Amelanchier utahensis-type (Utah serviceberry)

Utah serviceberry is found abundantly in the Sand Canyon Pueblo area today (personal observation 2008, 2009). The plant is documented as used by some Southwest Native Americans for a variety of purposes. The Hopi used the wood for bows and arrows and to make prayer sticks. Others used various plant parts for food (pomes) and in ceremony. The Ramah Navajo are recorded as using the stems and leaves for ceremonial purposes (Rainey and Adams 2004).

Buds and associated twigs. A new taxon for Sand Canyon, identification of these buds was made possible by charring small samples of all available angiosperm buds near in the vicinity of Sand Canyon in June 2008 and direct comparison with CCAC Herbarium specimens. All were ruled out as potential matches with the exception of Utah serviceberry. The ancient Sand Canyon Pueblo specimens were recovered in two forms: (1) an inner reproductive structure covered with sturdy coarse hairs that retain their shape when charred; and, (2) three enclosing bracts or leaves. These have a hard mottled surface and overlap in a consistent manner. There is a clear stalk attachment point. Measurements for the outer enclosing scale leaves are approximately 3 to 4 mm in length and 2 to 3 mm in width. Wood anatomy of the associated twigs was unclear due to first season terminal branches. I also compared the ancient specimens with *Amelanchier alnifolia* (Nutt.) (Saskatoon serviceberry), another native species observed in Montezuma County (Heil and O'Kane 2005:65).

Using the University of Victoria, Department of Biology Herbarium voucher specimens, this species was ruled out as the buds were clearly more elongated with narrower terminal buds (and apparently not representing a growth stage). *Amelanchier utahensis* was a consistent and comparable match with the ancient specimens. Photographs D.62-D.72 (Appendix D) document both modern uncharred specimens and the ancient charred remains recovered from additional flotation volumes.

Amelanchier/Peraphyllum-type (serviceberry/peraphyllum**)**

Wood (charcoal). Amelanchier and Peraphyllum wood are indistinguishable from each other at least when charred. Identifications to this dual category are made for this reason. The vessels in both are small, solitary, abundant, closely spaced, and evenly distributed. They grade in size becoming smaller in the latewood. Ring boundaries are distinct and vessel patterns are semi-ring porous to ring porous. Rays are thin, abundant, and discontinuous (Adams and Murray 2004).

Cercocarpus/Artemisia-type (mountain mahogany/big sagebrush)

Wood (charcoal). A diffuse porous ring pattern with widely spaced solitary vessels of variable size, this dual designation, *Cercocarpus/Artemisia*-type, is used as per Adams and Murray (2004) when neither mountain mahogany nor big sagebrush can be distinguished with confidence. In both types, rays are abundant, thin, continuous and discontinuous. The ring boundaries are indistinct but marked with widely spaced earlywood vessels (Adams and Murray 2004).

Cercocarpus-type (mountain mahogany)

Heil and O'Kane (2005:65) note that *Cercocarpus intricatus* S. Wats, and *C. montanus* (alderleaf mountain mahogany) are both local to the Sand Canyon area. *C. montanus* grows in abundance in the location of Sand Canyon Pueblo (personal observation 2008, 2009). Ethnographic records indicate that many Native American groups made use of the wood. The Hopi in particular used the plant for ceremonies (used in the midwinter ceremony), for prayer sticks, tools, and dyes (Rainey and Adams 2004).

Wood (charcoal). Description provided above. On cross section, background cells are highly light-reflective (Adams and Murray 2004) but unless the specimen is large enough to show more than one growth ring, identification is limited to *Cercocarpus/Artemisia*-type because of the similarities in cross-section morphology between the two woods.

Prunus/Rosa (chokecherry/plum/rose)

Wood (charcoal). Adams and Murray (2004) describe these woods are semi-ring porous with abundant, solitary, paired, or multiple vessels. The vessels are elliptic in the latewood and larger in the earlywood. Both *Prunus* and *Rosa* type have visible, abundant, wide, and continuous rays. Specimens identified to this category compare well with both *Prunus* and *Rosa* wood comparative specimens.

Purshia mexicana/Cowania mexicana/Stansburiana (cliffrose)

For notes on ethnographic use, see *Purshia tridentata*-type (bitterbrush). While it is difficult to distinguish between bitterbrush types, the leaves are diagnostic.

Wood (charcoal). See *Purshia*-type for description. Specimens identified to this taxon showed marked similarity to comparative material of this species.

Purshia tridentata-type (antelope bitterbrush)

Bitterbrush is documented in the ethnobotanical literature as used by only a few Native American groups. The Hopi used *Purshia stansburiana* (Torr.) Henrickson (Stansbury cliffrose) as a medicine and for ceremonial use. The bark was spun and woven into kilts worn by the snake priests (Moerman 1998:455). The fibers were also used for bedding, padding for cradleboards. *Purshia tridentata* leaves and twigs were used by Ramah Navajo in many of their rituals (Rainey and Adams 2004).

Leaf. Identification of antelope bitterbrush leaves is based on the presence of leaf tip prickles and rolled margins, which are lacking in *Artemisia tridentata*, or other *Artemisia*-type leaves which are very similar (Adams and Murray 2004). My comparative collection of local Sand Canyon Pueblo *Artemisia* and *Purshia tridentata* leaves shows that *Purshia* leaves also are more trifid than tridentate with three (to five) lobes more deeply incised than the typical tridentate leaf of *Artemisia* (photograph D. 57, Appendix D).

Purshia-type (cliff-rose/bitterbrush)

For ethnographic information, see *Purshia tridentata*-type (bitterbrush).

Wood (charcoal). The description of *Purshia*-type applies to *Purshia tridentata* and *Purshia mexicana*. The vessels are abundant and densely spaced at the ring boundary and more widely spaced in the latewood in these species. The vessel size is minute and all are solitary. Rays are thin, abundant, and discontinuous. This is a highly light-reflective wood when charred and shows distinct lobate patterned ring boundaries (Adams and Murray 2004).

Rosa-type (rose)[identified by its dual category of *Rosa/Prunus* or *Prunus/Rosa*-type]

Rose species are and were used by many Native American groups for a variety of purposes although there is a lack of information readily available regarding the use of *Rosa* (rose) species by Pueblo groups. Ethnographically, Hopi children are recorded as eating the pomes (Rainey and Adams 2004). The Navajo and Ramah Navajo are documented as using *Rosa woodsii* Lindl. var. *woodsii* (Woods's Rose) for medicine, tools, and ceremonial items (Moerman 1998:486).

Wood (charcoal). Specimens identified to this family are semi-ring porous to ring porous and are not easily distinguishable from *Prunus* (chokecherry). Specimens are identified as a dual category (*Prunus*/*Rosa*, or *Rosa/Prunus*) because of the similarity in cross-section morphology.

Salicaceae *(Willow Family)*

> He stripped the bark from a piece of willow and cut two pieces from it, each measuring from the tip of the second finger to the base of the thumb. They must always be of this length and sharpened at one end. On one, he trimmed a flat surface, painted them, first white, then green, the points black, the flat surface brown, with dots representing eyes and mouth. This he called woman. He took a turkey feather, saying, "This is an animal of the earth and lives only near water, hence it is emblematic or rain." He fastened it to the back of the two sticks with twine… He twisted a corn husk into the shape of a horn and placed in it some sacred meal and fastened it, too, to the sticks. Some sprigs of wild sage and snake root representing the growth of plants and good heart followed next. After he had finished this he called it *paho* (*baho*), rain feather. The chiefs whenever they held a sacred feast must not forget to prepare the *paho*, for this would show Sun, their father, that the people had not forgotten him.
>
> adapted from Alexander M. Stephen, *Hopi Tales*,
> "The Chiefs are Instructed in Prayer-Stick Making" as told by Müau wutaka
> (Stephen 1929:64-65)

Populus/Salix-type (cottonwood/willow)

Populus was used by the Hopi as material for making prayer sticks and other useful objects (Whiting 1939:23). For other ethnographic uses, see *Salix*-type (willow).

Wood (charcoal). *Populus* and *Salix*-type woods demonstrate many of the same morphological characteristics and can be indistinguishable when charred. Adams and Murray (2004) describe the wood as follows: vessels are solitary, paired, or found in multiples. They are abundant and densely spaced larger in size in the earlywood and grading to smaller in the latewood. Rays are abundant, distinct and thin with approximately 1-3 vessels between the ray and Ring boundaries are distinct but tend to be thin. I noted that the charred pith in *Salix* is well delineated with a bronze hue, very different from the star-shaped dull black piths of cottonwood. Unless clear matches with comparative specimens, all *Populus* or *Salix* woods are identified to the dual category of *Populus/Salix*.

Salix-type (willow)

Ethnographic records suggest that willow was used by many Native American groups. The Hopi made us of willow branches in roof construction and for ceremonial purposes (for prayer sticks, worn on the wrists of the kachinas)(Rainey and Adams 2004).

Wood (charcoal). Wood identified as *Salix*-type displays the morphological structure described by Adams and Murray (2004) as follows. Vessels are solitary, paired or grouped in multiples. They are densely spaced, abundant, and larger in the earlywood grading to smaller in the latewood. Ring patterns are semi-ring porous with the first row of solitary earlywood vessels making a distinct but thin ring. Only those specimens that matched the comparative specimens are identified to this taxon, otherwise the dual category of *Populus/Salix* is used.

Solanaceae *(Potato/Nightshade Family)*

Nicotiana-type (tobacco)

Specimens identified to *Nicotiana*-type are likely that of *Nicotiana attentuata* Torr. Ex S. Watson (coyote tobacco), the species of tobacco documented for Montezuma County, Colorado (Heil and O'Kane 2005:69). Tobacco has significant cultural import for Native American groups and is recorded as used as medicine and for ceremonial purposes. Rainey and Adams (2004) record that the Hopi use this species in many of their ceremonies and mixed with other plants for medicine. Moerman (1998:355) records that the Hopi use the plant only (and always) for ceremonial purposes. Whiting (1939:47) notes the use of the plant as a name for a Hopi clan suggesting the plant's significance to the Hopi in the recent past.

Seed coat. This specimen has the size, shape and distinctive reticulate patterning (jigsaw-puzzle shapes) on the surface typical of *Nicotiana*.

Physalis longifolia (common/longleaf groundcherry)

Many Native American groups are documented as using common groundcherry for food (Moerman 1998). The Hopi recognize two species of *Physalis* (*P.longifolia* and *P.hederifolia* var. *fendleri* (Gray) Cronq.). Heil and O'Kane (2005:69) record three species of groundcherry for Montezuma

County (*P. crassifolia* Benth., *P. hederifolia* A. Gray (three subspecies), and *P. longifolia* Nutt.var. *longifolia.* A number of common groundcherry seeds were found charred and uncharred in association with charred and uncharred ground squash seeds (see *Cucurbita*-type), in midden sample FV14.

Seed. Seeds are circular to ovate in face view. The surface is covered with a reticulate surface (Adams and Murray 2004). Specimens were recovered both charred and uncharred in association with other charred and uncharred remains (photograph D.73, Appendix D).

Unknowns: Botanical materials

Achenes and seeds, unknown

Whenever possible unidentified seeds are named as "unknown" with a genus or species-type assigned as a descriptor. These designations represent a tentative identification. Due to the number of unidentifiable uncharred seeds, only those with some descriptive characteristics are noted here.

<u>Achene, unknown – "*Corispermum*"-like (bugseed/tickweed-like) (Chenopodiaceae/Goosefoot Family)</u>

"Corispermum"-like is a descriptor for this achene that bears some resemblance to the species in various ways. It is oval in face view and flat in cross-section, and has a naturally glossy surface, "as if varnished" (Martin and Barkley 1961:152), and an encircling wing. At the base of the wings, two minute, tooth-like style bases are present. Although some morphological similarities with *Corispermum*-type seeds is noted, the size is smaller (3.0 mm and under) which may or may not be significant as evidence of the encircling wing is merely suggested (photograph D.77 and D.78 [Appendix D]). Rainey and Adams (2004) note that the Navajo named this plant although no uses were given.

<u>Seeds unknown, various</u>

A descriptive category that encompasses all seed and seed-like material that due to degradation or fragmentation is not categorized elsewhere.

<u>Seed, unknown "*Alyssum*"-like (madwort-like) (Brassicaceae/Mustard Family)</u>

This uncharred, dehydrated seed measures 1 mm in diameter. Shape is obovate in outline, flat in cross-section. The apex is pointed and the base is rounded. A thin, narrow-margined wing is present that appears slightly puffed up. The surface is glossy and yellow-brown. No ethnographic use was found for *Alyssum* L. (madwort)(photograph D.74, Appendix D).

Seed, immature unknown, ovoid "*Croton"*-like (croton-like) (Euphorbiaceae/Spurge Family)

The seed is ovoid in face view, narrowly ovate in cross-section and is uncharred. It appears to have a slight indent forming a ridge around the outside and measures approximately 2 mm in length, 1.25 mm in width. Thickness is estimated at .75 mm. The seed is similar in morphology to *Croton* (croton) (photograph D.79 [Appendix D]). Stevenson (1915:45) writes of croton (Zuni "coyote leaf") as a medicinal tea. Moerman (1998:185) records the use of croton for various purposes ethnographically by Native American groups, the Hopi are recorded as using the plant as food for wild doves. Moerman (1998:185) records that some Pueblo groups utilize croton in a variety of ways for medicine, fodder, as well as for other purposes.

Seed, immature round

This immature seed is similar in color and texture to "*Croton*" (above). The specimens are flat and measure approximately 1 mm in size. All are uncharred. See photograph D.91 (Appendix D) for examples.

Seed, unknown elliptical

The charred seed is elliptical (elongate) and sturdy and appears to have a finished edge. Almost triangular in cross section, it may have tooth-like style bases at the apex. The base is rounded and appears highly polished. Specimen measures approximately 1.25 mm in length by almost 1 mm in width with some epidermis (photographs D.92 and D.93 [Appendix D]).

Seed, unknown plano-convex

This highly degraded, nearly round, charred seed measures 2.75 length x 2.5 mm width. "Plano-convex" may be a misinterpretation of morphology as it may be only ½ a seed. The surface is dull with minute pitting and no evidence of epidermis. At one end there is a C-shaped dip. A small fragment is missing on the distal surface (photographs D.94 and D.95 [Appendix D]).

Seed, unknown "*Plantago*"-like (plantain-like) (Plantaginaceae/Plantain Family)

This ovate seed measures 2.25 mm in length and 1.5 mm in width. Thickness is estimated to be approximately .75 mm. The specimen is degraded to the point of having no discernable surface characteristics except for the hollowed out area in the center. *Plantago* seeds normally range in size from 1.5 – 4 mm in length, which puts this unknown seed into a similar size category. The hollowing out of the center does not appear to be mechanical but rather characteristic of the seed itself. Because it is clearly degraded and identification is not without ambiguity, it has been assigned as an "unknown" seed and its general characteristics suggested by the title, "*Plantago*-like" to be conservative (photographs D.81 and D.82 [Appendix D]).

<u>Seed, unknown triangular/biconvex</u>

This degraded biconvex seed is circular-ovate in shape and shows pitting on a dull surface with a clear attachment point/hilum on a rounded-triangular base. Some surface epidermis may be present on one side where there is a small, rounded projection. The seed clearly puffed up on charring, similar to Cheno-am-type seeds that often show triangular sides versus their rounded biconvex appearance when charred. This unknown seed measures approximately 2.5 mm in length by 2.0 mm in width. Thickness is approximated at 1 mm (photograph D.80 [Appendix D]).

<u>Seed coat, unknown "*Brassica*"-like (Brassicaceae/Mustard Family)</u>

This seed fragment represents a little over half the original size. The hilum is easily seen, elliptical in shape and surrounded by a protruding ridge. The remains of a stalk or other tissue can be seen in the center. The seed coat is thick, measuring just under .25mm. The overall size of the seed is estimated to be 2 mm in diameter, round to ovoid in shape, slightly flattened laterally. There is a reticulate pattern, in rows evident on the entire surface. The descriptor "*Brassica*" is tentative. Musil (1948:22) notes that 2 mm in diameter for *Brassica* are considered to be relatively large (2-3 mm in diameter). The patterned cordlike reticulations are suggestive of *B. rapa* (field mustard)(26). *Brassica campestris* L., *B. incana* (L.) DC, and *B. tournefortii* Gouan are noted to be found in the Four Corners San Juan River Drainage area, specifically in Arizona and Utah (Heil and O'Kane 2005:26). Harrington (1954:281) notes that only *Brassica arvensis* (*Sinapis arvensis*) is found in the western part of Colorado. *Brassica* is designated native of Eurasia although distributed at various places in the United States (281; USDA NRCS 2009). The specimen was compared with herbarium vouchers but no definitive identification is offered. Ethnographically, a few North American Native groups are recorded to use *Brassica* as food. See photographs D.75 and D.76 (Appendix D).

<u>Seed coat, unknown – *Sisymbrium/Thelypodiopsis*-type (hedgemustard/tumblemustard) (Brassicaceae/Mustard Family)</u>

This charred specimen is half of a seed broken longitudinally. The shape is oblong-truncate in face view, somewhat wedge-shaped in side view with a shallow oval shaped notch at the base. Size is approximately 1.5 mm in length. The surface is dull and slightly roughened. It is similar in morphology to *Sisymbrium altissimum* (tall tumblemustard) or *Thelypodiopsis* sp. (Durango tumblemustard, westwater tumblemustard, and juniper tumblemustard [USDA NRCS 2009]). No herbarium sample was reviewed and identification is tentative. Stevenson (1915:85) documents the Zuni use of *Thelypodium wrightii* A. Gray (Brassicaceae) as a "medicine" whereby the seeds are removed from the pods, ground and planted with beans as "sandhill-crane beans all medicine" that causes the bean crop to be abundant. See photographs D.89 and D.90 (Appendix D).

Unknown: Miscellaneous

Buds, unknown

Only the buds of *Artemisia tridentata*-type, *Amelanchier utahensis*-type, and *Ephedra viridis*-type have been identified confidently. Others are noted below.

<u>Bud unknown, type 1</u>

This 2.5 mm long "bud" (fruit?) with immature leaves or bracts at the base, are blunt-ended on one side. Very similar in shape to the uncharred *Lycium pallidum* fruit in the CCAC comparative collection (Adams and Adams 1987), but size is incomparable (photographs D.98 and D.99 [Appendix D]).

<u>Bud unknown, type 2</u>

Measuring 1.5 mm in length by .5 mm in width and thickness, this elongated bud has a well-rounded base with no attachment and a short curved apex. A portion is missing from one side revealing ambiguous tissues within. It has a slightly rough surface texture (photographs D.100 and D.101 [Appendix D]).

<u>Bud unknown, type 3</u>

Bud type 3 (the largest specimen) measures approximately 4.0 mm x 2.0 mm. Recovered in the 1.4 mm screen of a midden 4 (Nonstructure 1214) sample. These buds have a globose shape with a slight narrowing at the apex to form a rounded point. Observable interior tissues display small, homogenous parenchymal cells with no obvious differentiation in the small portion seen. As far as it is possible to tell, each bud has two semi-elliptic leaves at the base still attached to a stem (photographs D.102 and D.103 [Appendix D]).

Bud unknown, type 4

Approximately 1-1.5 mm in diameter, this distinctive and tightly compact bud has large attachment point and bracts that flare out at the tip. It does not compare favourably to *Ephedra*-type developing cones or *Amelanchier utahensis*-type buds (photographs D.104 and D.105 [Appendix D]).

Bud unknown, type 5

Triangular in face view, this tightly compact bud has a wide attachment point complete with the remnant of a stem. The whole bud measures approximately 2 mm in both length and width. Thickness is approximately 1.5 mm. Bracts are almost subulate from the midline to the apex ending in a point. It flares below the midpoint to a wide, flat base. It does not compare favourably to any other bud recovered (photographs D.106 and D.107 [Appendix D]).

Disseminules, unknown

Disseminule, unknown

A category used to name a variety of small to minute unknown reproductive parts that cannot be identified to genus or species and are challenging to describe.

Fiber, miscellaneous

Specimens identified to this category reflect thread-like plant tissue. Uncharred fibers appear to be modern, often in a variety of colours. These likely represent contamination.

Filament, unknown

Specimens identified to this category are also thread-like in appearance but much finer and more fragile. A botanical definition of the term filament does not necessarily apply to these samples (filaments being the stalk of a stamen, the pollen-producing structure of a plant [Benson 1959:655,663]). This category reflects more the diameter of the specimen. This also applies to the category "Hair/Filament."

Fruit

"Sand Canyon Fruit *Malva*-type" (Malvaceae/Mallow Family)

These minute charred remains compare well to *Malva*-type semi-segmented indehiscent fruit schizocarps. Specimen sizes range from 1-1.5 mm in diameter. Typical modern *Malva*-type schizocarps are in the range of 5 mm in diameter. The charred specimens recovered from Sand Canyon Pueblo flotation samples have rounded edged segments and a compressed round center taking up about 1/3 of the total size making it a best fit in general morphology (excluding size) for *Malva neglecta* (common mallow). On the dorsal side, a minute attachment point is noted for the peltate stalk. These specimens remain "unknown" based on the incomparable size but are likely due to specimen immaturity at the time of carbonization. Experimental charring of modern common mallow fruits did not show evidence of shrinkage. It is plausible that the leaves of the plant were gathered for greens as is noted in the ethnographic record (Moerman 1998:334-335). *Malva* are annual or perennial herbaceous plants with a depressed and disk-like fruit with numerous carpels that are indehiscent and separate when mature (Harrington 1954:369). The carpels are not separate providing further support to the inference that the specimens are immature. Possible candidates include:

1) *Malva parviflora*. Very few records of this plant exist, but Harrington (1954:370) records the plant in north-central Colorado.
2) *Malva crispa.* Located in north-central Colorado.
3) *Malva neglecta.* Also called *M. rotundifolia*, as weed in waste places, gardens, and fields and naturalized from Europe.

M. neglecta has 12-15 mature carpels and is an abundant weed in gardens and waste places found throughout much of North America from May to October (Gleason 1968:525-527). One Sand Canyon specimen appears to have at least 15 carpels. USDA NRCS (2009) records that *M. neglecta* (common mallow, also called buttonweed, cheeseplant or cheeseweed) is present in Colorado. Heil and O'Kane (2005:46) record the presence of *M. neglecta* in Montezuma County. The Ramah Navajo used *M. neglecta* for medicinal purposes. The Pima are recorded as using *M. parviflora* as a starvation food (Moerman 1998:334-335). See photographs D.59-D.61 (Appendix D).

Nutshell

<u>Nutshell fragment, unknown type</u>

A thick-shelled nutshell fragment that measures approximately .75 mm on one side. The specimen is 3-mm long and is too thick for pinyon pine nutshells or oak acorn that are locally available near the pueblo today. The specimen is too small to identify with certainty (photographs D.96 and D.97 [Appendix D]).

Rind

<u>Rind, unknown type</u>

Shape is irregular with a somewhat smooth surface, folded to a narrow blunted end. There are few rectangular, isodiametric cells on the interior surface but most of the interior cells are either burned away, or specimens represent only the outer epidermis. It may be from the squash or gourd family but too ambiguous to identify with confidence.

Stem

Stem (type E)/*Juncusi*-type?.

These 1-mm in diameter stem segments are solid with a hard outer surface that is smooth and slightly dull. The specimens are rigid and break cleanly into .5-1.0-mm segments. They are very similar in internal structure to that of *Phragmites* (reed) but the size is incomparable. These stems were found in association with *Eleocharis*-type seeds. See photographs D.24-D.25 (Appendix D).

Tissues and miscellaneous

Mealcake, unknown

A small "mash" of tissues was found in a 1.4 mm screen and appears to be fragments of some botanical tissues, crushed together. Some of the material is similar in structure to parenchymal-like cells. Other tissues appear to be remnants of epidermis.

Monocotyledon rind, rugulose surface texture

This rind tissue was recovered in a 1.4 mm screen and measures 5 mm in length by 3 mm in width and estimated to be less than .25 mm in thickness. Surface texture is wrinkled and compares favourably to a rind sample of C*ucurbita*. A row of fibrovascular bundles is evident (photographs D.108 and D.109 [Appendix D]).

Tissue, epidermis-type

Specimens identified to this category reflect what appears to be exterior tissue that does not exhibit well-definable surface characteristics to enable it to be categorized elsewhere.

Tissue, nodulose-type

Found in many samples, these tissues are highly fragmented and angularly broken. The outer epidermis or surface is covered with small bumps and can be quite light reflective. The specimens are tissue paper-thin (photographs D.111 and D.112 [Appendix D]).

Tissue, parenchyma-type

Specimens identified as parenchyma-type reflect the most common type of internal plant cell tissue. Cells are thin-walled, vary in size and shape and are too fragmented to be characterized elsewhere.

Tissue, papillose-type

These fragments range from 4-7 mm in length by 1-2 mm in width. They often display curled edges. Described as "papillose," they have minute rounded projections, some of which are sharply pointed. The specimens are similar in surface morphology to charred *Yucca baccata* leaf fragments under magnification (10x or greater) in the my comparative collection. See photographs D.114-D.116 (Appendix D).

Tissue, rugulose-type

A small tissue fragment measuring 2 mm in length by 1 mm in width, thickness is estimated to be approximately .25 mm. Its rugulose surface texture is highly light reflective (photograph D.110 [Appendix D]).

Tissue, type 1

Unknown tissue type 1 is charred and has two major parts, a portion of a berry-like structure and a stalk. The specimen measures 5.5 mm in length by 4 mm in width. Thickness is estimated at approximately 2 mm. The stalk measures 2 mm in length and is 1 mm thick. The outer surface of the "berry" is folded and dull with light reflective rows of cells within. The structure is broken off bluntly at the apical end and epidermal tissue is frayed and divided into finely textured sections (photographs D.117 and D.118 [Appendix D]).

Tissue, type 2

Finely folded, highly light reflective, the specimen is a "satiny" tissue fragment that appears to be epidermal. The specimen measures 1.5 mm in length by 1 mm in width. Thickness undeterminable. Surface texture is slightly rough and appears somewhat similar to the fine, minute fragments of charred *Zea mays* paleas and lemmas, but much more folded (photograph D.119 and D.120 [Appendix D]).

Tissue, type 3

This tissue displays some similarities with the previously described "Seed, Triangular/Biconvex-type" in that it has a rounded projection on one side located in the center of the specimen. One edge appears to flatten suggesting a papery wing or encircling embryo. Only a portion is present and could be part of an embryo. It is 3.25 mm in length by 3.0 mm in width. Thickness is estimated around .5 mm. The internal cells are homogenous with small, rounded cells/pits of equal size (photographs D.121 and D.122 [Appendix D]).

Tissue, type 4

Almost trapezoidal, this specimen is degraded and shows no observable characteristics of a seed, yet it seems to have prescribed edges and shows some evidence of a surface texture of minute pits on one side. It measures 2.5 mm in length by 2 mm in width. Thickness is estimated to be approximately 1.5 mm at thickest point. There is some very fine, sharp projections or points (muriculate) evident over most of the surface that are difficult to view and require high magnification. The remainder of the tissue is small homogenous rounded cells. It may be puffed up due to charring (photographs D.D. 123 to D.125 [Appendix D]).

Tissue, type 5

Delicate, finely textured flakes of light reflective tissue, these minute fragments are irregularly shaped, sometimes showing parallel striations on two surfaces (dorsal and ventral) and are found in the .71 and .25-mm screens. Often specimens are curved. They compare very favourably to fine charred *Zea mays* kernel epidermis (experimentally charred *Chapalote mays* cobs, kernels, glumes and associated tissues). Tissue type 5 may support an interpretation of worked/ground *zea mays*. See photographs D.126-D.128 (Appendix D).

Tissue, type 6

Delicate, finely textured oval shaped tissue with measurements of 2.5 mm in length by 2.0 mm in width. Thickness is estimated at approximately .5 mm. Striations are most notable on the outer epidermis at one end. Faint dimpling can be seen across the entire surface. Internal cells do not show the clear patterning of the outer surface (photographs D.129 and D.130 [Appendix D]).

Tissue, type 7

Dense homogenous and minute cells make up this hard, rounded tissue measuring 4 mm in length, 4 mm in width, and 3 mm in thickness. Fragments of the epidermis are light reflective, polished, and very thin. The tissue is almost heart-shaped with a centrally located furrow. Light reflective epidermal tissue is present on parts. The density and size of the internal cellular structure is like that of *Zea mays* cupules that also have hard, packed, and minute cells. See photographs D.131-D133 [Appendix D]).

Tissue, type 8

This seed-like tissue measures 2.5 in length by 2.0 mm in width. Thickness is estimated at approximately 1.5 mm. The general shape is round with upturned edges with a slight rounded projection in the center on what is perhaps the ventral surface. Edges are rough and degraded so the shape is tentative. It appears seed-like in that there is some slightly splitting on the edges revealing an interior cavity that has collapsed. Some wrinkled (rugulose) epidermis is present. Type 8 is non-wood tissue. See photographs D.134 and D.135 (Appendix D).

<u>Type 2 Unknown</u>

This unknown specimen was recovered in a firepit and compares favourably to Adams (1993a:209) description of a Duckfoot site unknown botanical labeled Type 2 unknown. The Duckfoot specimen is described as circular in face view, lens-shaped in cross-section. Two distinct surfaces are noted, one slightly convex with eight small knobs, and the other is rough and jagged and possibly once attached to the plant. Measurements are 2.5 mm in length, 2.5 mm in width and less than 2.0 mm in thickness and may be an over-wintering bud cluster (Adams 1993a:209; Adams and Murray 2004). The Sand Canyon specimen is comparable and likely also reflects an over-wintering bud as it also has a ragged attachment point. See photographs D.137 and D.138 (Appendix D) showing specimens from Sand Canyon Pueblo.

Unknowns: Nonbotanical materials

> The old man was sent by his chief to teach the people how to prepare the prayer-stick and how to sing and dance so the young people might be reformed. He prepared himself, putting on a beautifully woven white girdle, a red rope around his neck. He placed bracelets of bright green stone which sparkled in the firelight like snake's eyes, the stone called *chosboshi*, or shining eyes. The old man gathered twigs of spruce and began to sing and dance. He told them they must do the same if they wanted rain or snow or good crops.
>
> adapted from Alexander Stephen, *Hopi Tales*,
> "The Chiefs are Instructed in Prayer-Stick Making"
> as told by Müau wutaka (Stephen 1929:64-65).

Mineral

<u>Ferrian Illite/Glauconite</u>

Identification of Ferrian Illite/Glauconite is credited to Dr. M. Raudsepp and his team at the Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, who tested specimens by x-ray powder diffraction and scanning electron microscope analysis of what was initially believed to be a "turquoise" rock. In consultation with Dr. John Greenhough of the University of British Columbia, Okanagan, several characteristic grain types are described: rounded (worked by stream, creek or water to become rounded) and others angular or "freshly" broken (archaeologically "ancient" versus geologically "ancient'"(Greenhough and Raudsepp, personal communications 2009). Greenhough suggests that the modified grains may have been used as a grinding agent.

X-ray diffraction results show that these specimens are typical clay minerals found in sedimentary rock outcrops. The turquoise green color is due to iron content and the highest percentage mineral content in the specimens is that of glauconite, common in ocean deposits like the Green River Formation (Raudsepp, personal communication 2009). This mineral also occurs in the Morrison formation in Montrose County, Colorado, and can only be identified by x-ray and microscopic analysis (Keller 1956). Glauconite is a mica mineral formed "during marine diagenesis under restricted conditions in areanceous sedimentary rocks; the typical coloring agent in "greensands" (a sandstone)(Anthony et al. 1995:232). There are four geologic formations that contain this material in the Mesa Verde National Park area within approximately 30 kms of Sand Canyon Pueblo. All Cretaceous in age, two are of nearshore marine origin (Cliff House Sandstone; the most recent at 75-80 Ma, and the Point Lookout Sandstone at 82 Ma)(Carrara 2009).

Large quantities (over 15,000 pieces) were counted in the .25-mm screen portion of exploratory sample SC9 (midden 1214). Only one fragment was located in an additional flotation sample (sample FV14) from the same deposit. The specimens were found in association with pale orange quartz fragments. No record of the mineral has been documented in flotation samples at Sand Canyon Pueblo or in any other source I could find. The abundance of the grains suggests that the sample from which the specimens occurred represented a specific unknown activity suggestive of grinding. The colour is of interest and a brief description of some cultural associations are presented here to suggest that the grains captured in these flotation samples are cultural in origin:

Turquoise is an important Hopi colour and featured in Stephen's (1929:12 studies of Hopi mythology). Stevenson (1915:36) records that vegetation is symbolized by blue-green on the sacred dance-kilts worn by Zuni rain-makers. "Turquoise" flowers, *Ziminesia exauriculata* Rob. & Greenm. Rydb. (crownbeard) from the Asteraceae/Aster Family were ground ethnographically and used as a cure for rattlesnake bite (Stevenson 1915:53). The mineral turquoise (not the grains recovered in the samples) is noted to be present in large quantities at Pueblo Bonito in Chaco Canyon, New Mexico, with the highest degree of mining occurring after the depopulation of the Mesa Verde area and the collapse of the Chaco Phenomenon (Mathien 2001). Micro-pieces of turquoise have been found in pithouses, kivas and graves in great houses (108, 111, 113). The importance of the mineral turquoise and the color blue-green noted for prayer-sticks in Hopi Emergence narratives may have some connection (Stephen 1929:12, 30). I refer to Ford (1980) and the emphasis on the sacred Tewa colors for corn and his discussion of the cognized environment from Rappaport (1967:237 in Ford 1980:18). I suggest that these "turquoise"-coloured grains may have been used as a special grinding agent with possible links to the deeper past activities with “real” turquoise. In discussions with Steven Copeland at Crow Canyon, these minute turquoise “green” rocks have been questioned and further investigation might be of interest (personal communication 2009). See photographs D.151-D.153 (Appendix D).

Beetle (Order Coleoptera)

Harpalus-type beetle (Family Carabidae)

Identification of this insect type is based on the remains of elytra (forewings) that are sharply pointed at the apex and blunt at the attachment point. The wings are elongated and deeply incised with longitudinal grooves. There are many similar species but all fall under the order Coleoptera (Beetle). *Harpalus* sp. live in underground debris and their season of activity is July. This type measures approximately 1.5 cm in length (Alden et al. 1999: 211). The wings were recovered sample FV14 from midden 1214. I tentatively identify the wings to this genus but did not consult with a specialist.

Sutton (1995:278-279) discusses archaeological evidence of intentionally stored insect caches for food (one at Mantles Cave, Northwestern Colorado) and seed caches where insects appeared to be intentionally kept alive for consumption with the seeds at a later date, a practice supported by ethnographic records. Coprolites in the Southwest have been found to contain beetle, grasshopper, and unidentified insect parts at Antelope House Pueblo in Arizona (282). These remains may also reflect insect infestation or modern contamination. I do not think they are charred or necessarily modern. Hopi cosmological associations with the black beetle and death recorded by Whiting (1939) suggest intriguing inference potential for these remains. See photographs D.154 and D. 155 (Appendix D).

Termite (Family Kalotermitidae)

Adams (1984:30) identified and described wood-dwelling termite fecal pellets from Southwestern archaeological sites noting that termites have been present in the continental U.S. for millennia, consisting of approximately 40 native species. Termite fecal pellets are described as small (found in the .71 to .25 mm screen for the SCP samples) with six hard oblong surfaces. Longitudinal ridges are visible between the surfaces. One end is tapered and the other rounded. The interior is homogeneous and solid. Specimens are both charred and uncharred in some Sand Canyon Pueblo samples. As Adams (1984:41) notes, the identification and interpretation of insect remains from archaeological sites is a rich source of information. The identification of fecal pellets as termite evidence has provided a line of evidence to support the re-use of termite-infested wood in SCP fires. I argue that the presence of termite fecal pellets also supports my contention that structural beams would have been replaced and an explanation for later tree-ring cutting dates at Sand Canyon Pueblo.

Land Snail (Class Gastropoda)

The distribution of terrestrial snails (Mollusca) is affected by environmental factors such as temperature and rainfall. Evans (1969) notes that a "change in the value of one of these may be reflected in a change in the distribution and abundance of one or more species" and slight climatic changes can effect populations providing indicators of climate change even more fine-tuned than the pollen record. Dr. Manuel Palacios-Fest, Terra Nostra Earth Sciences Research of Tucson, Arizona, identified the following snails from photographs.

<u>*Pupoides*-type (Pupillidedae)</u>

This weathered (not charred) land snail, whorl-type was found in a kiva hearth (exploratory sample FV8), this specimen may represent *Pupoides hordaceus* Gabb, 1866, Ribbed Dagger. The species is recorded to be associated with calcareous substrates and dispersal limited to approximately 1 km unless through passive transport by people, birds, animals, etc. (Patterson et al. accessed April 30, 2010). This species is common in prairie environments (grasslands)(Manuel Palacios-Fest, personal communication 2010). Struever and Holton (1979) photographed this type of land snail type from the Koster Site excavations in Illinois. See photographs D.156-D.158 (Appendix D).

<u>*Vertigo*-type (Pupillidedae)</u>

This whorl-type land snail was recovered in sample FV11 from a midden in block 200. Species richness is associated with carbonate cliff habitats with a small territory as terrestrial gastropods typically move to find food or reproduce only (limited to approximately 1 km). The species is common to prairie environments (grasslands)(Manuel Palacios-Fest, personal communication 2010)(photographs D.159 and D.160 [Appendix D]).

Unknown

This is a specimen measuring approximately .5 mm in length, .25 mm in width and thickness (estimated). It appears "mushroom"-shaped with stalk. May be botanical (photograph D.143 and D.144 [Appendix D]).

Spherical Bodies

<u>Black Spherical Body</u>

Completely round, black, and charred, these minute specimens are generally less than 1 mm in diameter and are composed of undifferentiated homogeneous material. Surfaces are dull and even.

White Spherical Body

Similar in all aspects to black spherical bodies but are white in colour with the same homogenous interiors. See photographs D.145 and D.146 (Appendix D).

Appendix D: Sand Canyon Pueblo flotation sample specimen photographs

Scale is in millimeters, some computer enlargement in *iPhoto* for clarity.

Domesticated plants
Poaceae (Grass Family)
***Zea mays* (corn/maize)**

D.1 Charred *Zea mays* glume (25X magnification)

D.2 Charred *Zea mays* kernel embryo (25X magnification)(2 views)

D.3 *Zea mays* kernel embryo showing growing tip (30X magnification)

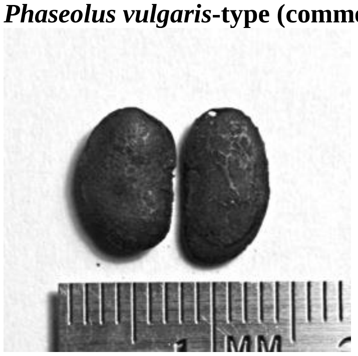
Cucurbitaceae (Cucumber Family)
***Cucurbita moschata*-type (butternut/winter crookneck squash)**

D.4 Uncharred but ancient *Cucurbita moschata*-type seed fragment (7X magnification)(3 views)

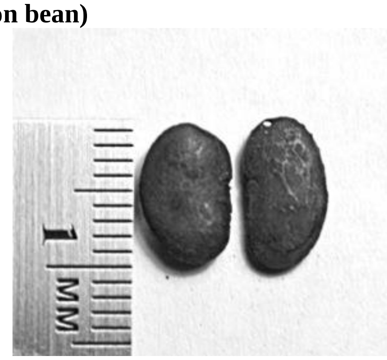
D.5 D.4 (computer enlarged) showing rim fringe diagnostic of *C. moschata*

D.6 (D.5 computer enlarged)

Fabaceae (Pea Family)
***Phaseolus vulgaris*-type (common bean)**



D.7 Charred *Phaseolus vulgaris*-type bean (left) and cotyledon (right)(2 views)

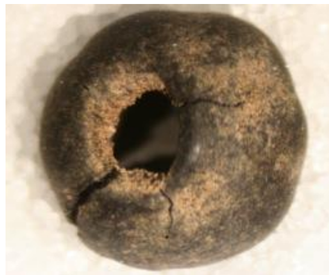


D.8 Charred *Phaseolus vulgaris*-type bean (left) and cotyledon (right)

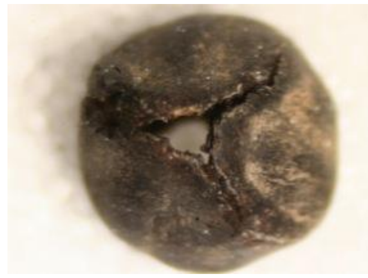
Wild plants
Gymnopsperms

Cupressaceae (Cypress Family)
***Juniperus osteosperma*-type**

D.9 Charred modified *Juniperus osteosperma*-type seed, (.7X magnification)(3 views)



D.10 D.9 (enlarged) showing drill hole



D.11 D.10 opposite view

Ephedraceae (Mormon-tea Family)
***Ephedra*-type**

D.12 Modern *Ephedra* stem with cones (author's comparative collection)

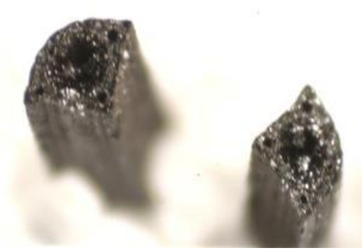
D.13 Charred *Ephedra*-type stem with cones, FV14 midden sample (35X magnification)

D.14 Charred *Ephedra*-type stem with cones, FV14 midden sample (25X magnification)

Pinaceae (Pine Family)
***Pinus*-type**

D.15 Charred *Pinus edulis*-type needle fragments (20X magnification)

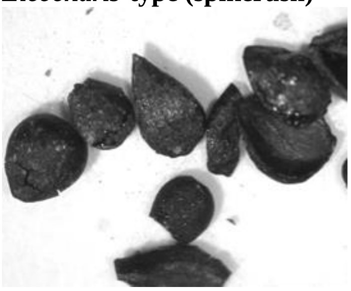
D.16 Charred *Pinus edulis*-type needle, sample FV4, firepit (cross-section, 30X magnification)



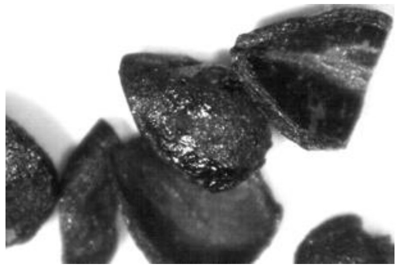
D.17 *Pinus ponderosa*-type needles in cross-section (author's comparative collection) (30X)

Wild plants
Monocotyledonea (Monocotyledons)

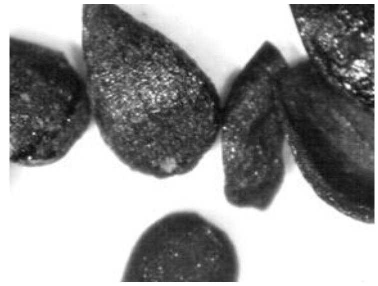
Cyperaceae (Sedge Family)
***Eleocharis*-type (spikerush)**



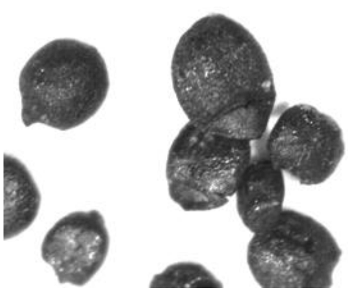
D.18 Charred *Eleocharis*-type achenes, interiors and seed coats (25X magnification) recovered from sample SC9 and FV14 midden



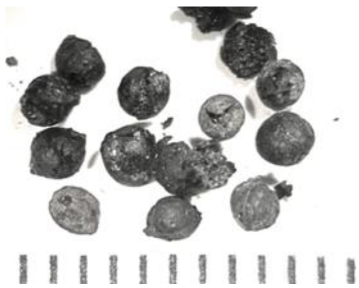
D.19 (D.18 at 45X magnification)



D.20 D.19 (45X magnification). Note the horizontal striations and thick outer coat typical of *Eleocharis* species

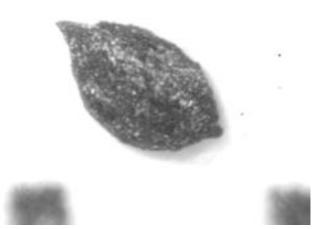


D.21 A selection of charred *Eleocharis*-type achene interiors. Note the large tubercles in these specimens (25X magnification)

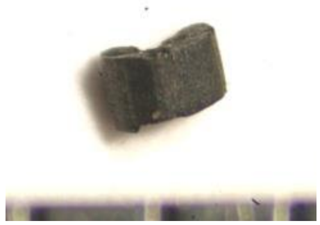


D.22 Charred *Scirpus*-type (bulrush) achenes (cf) (10X magnification)

Juncaceae (Rush Family)
***Juncus*-type (rush)**



D.23 Charred *Juncus*-type (cf) achene. Similar specimens were recovered in samples from a kiva hearth (FV10) a midden (SC7) and trash (SC10)

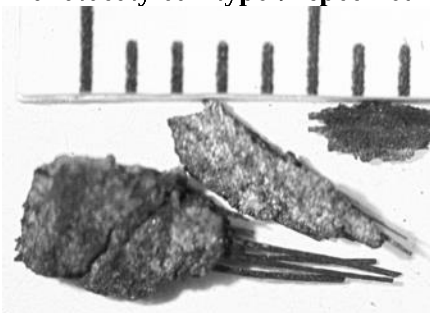


D.24 Originally thought to be a grass stem (‘type E’) based on recovery in association with abundant grass stem types, (SC9/FV14 sample midden)

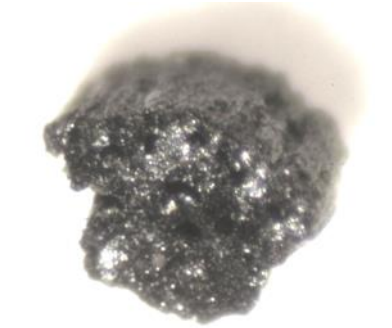
D.25 Specimen B.27 cross-section showing solid interior typical of *Juncus* species

Wild plants
Monocotyledonea (Monocotyledons)

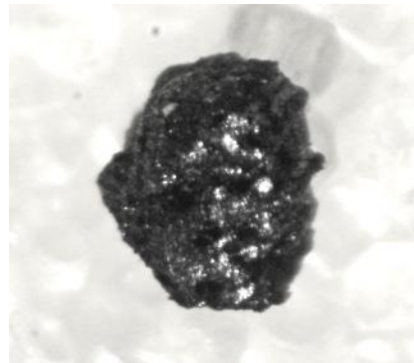
Monotocotyleon-type unspecified



D.26 Charred monocotyledon-type leaf tissues showing fibrovascular bundles from trash sample (FV15)(10X magnification)

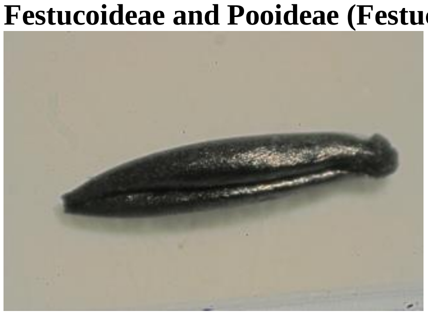


D.27 Charred monocotyledon-type stem segment/fragment, cross-section view showing vascular bundles and ground tissue (45X magnification)

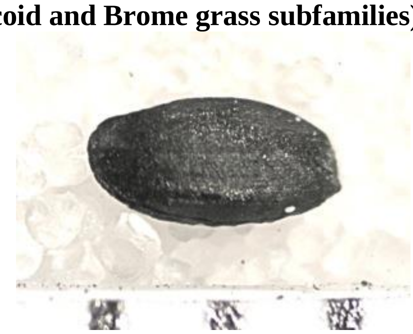


D.28 Charred and degraded monocotyledon-type stem fragment, cross-section view showing vascular bundles and ground tissue (15X magnification computer enlarged)

Poaceae (Grass Family)
Festucoideae and Pooideae (Festucoid and Brome grass subfamilies)

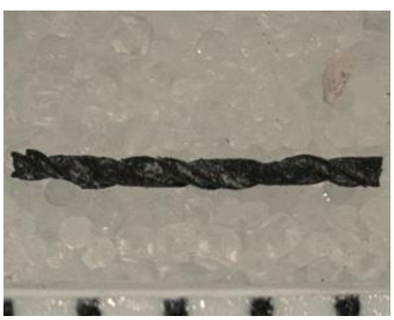


D.29 Charred *Bromus*-type (brome grass) caryopsis (3 mm in length)(35X magnification)

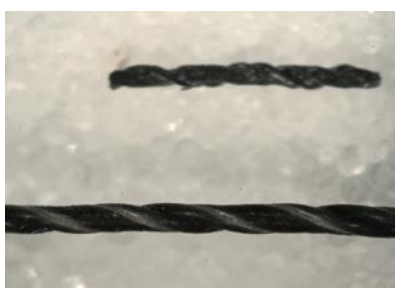


D.30 Charred unknown festucoid-type caryopsis, dorsal view showing embryo depression (right)(15X magnification). Firepit sample FV4

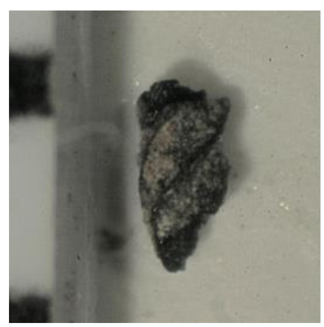
D.31 Specimen B.30 ventral view showing venation (20X magnification).



D.32 Charred (cf) Stipa comata-type (needle-and-thread grass) awn



D.33 Specimen seen in image B.30 (upper image) compared with a modern uncharred comparative specimen (lower image)



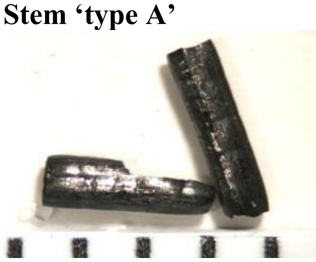
D.34 Charred Stipa comata-type awn fragment (trash accumulation sample FV16)(45X magnification)

Wild plants
Monocotyledonea (Monocotyledons)

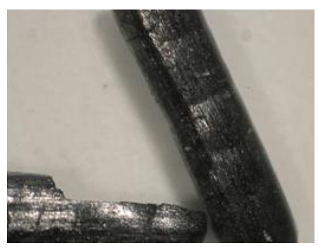
Poaceae (Grass Family)
Festucoideae (Festucoid Subfamily)

D.35 Charred Stipa/Oryzopsis hymenoides-type (Indian ricegrass) caryopsis (center) and Amelanchier utahensis buds (15X magnification, computer enlarged)

Poaceae (Grass Family)
Unknown types
Stem 'type A'

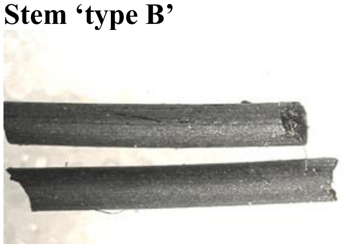


D.36 Charred stem 'type A,' characterized by highly light reflective satiny surface. Typical of grasses these specimens have hollow interior (2 views)(10X magnification)

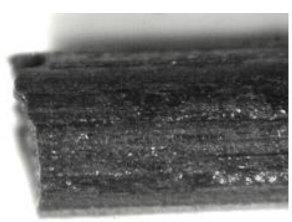


D.37 Specimen seen in image B.36 at 35X magnification. Recovered in samples from block 1200 midden samples (FV14, SC9), trash accumulations in the great kiva (FV17) and block 1500 (FV20)

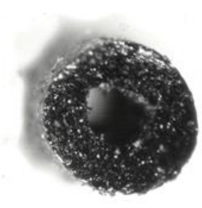
Stem 'type B'



D.38 Charred stem 'type B.' These sturdy hollow stem segments break cleanly and have a dull surface (15X magnification)

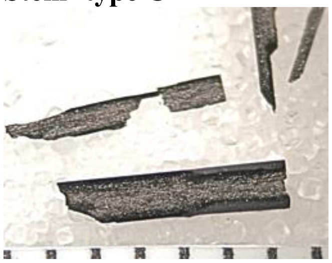


D.39 Charred stem 'type B' showing surface (45X magnification)

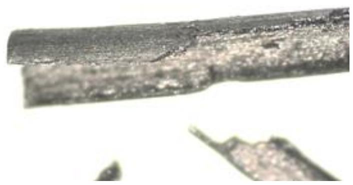


D.40 Charred stem 'type B' cross-section view showing hollow interior typical of grasses (45X magnification)

Wild plants
Poaceae (Grass Family)
Unknown types
Stem 'type C'



D.41 Charred stem 'type C' (10X magnification)(3 views)

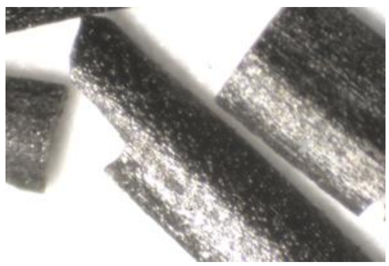


D.42 Charred stem 'type C' showing thin, fragile structure (similar to tissue paper)(25X magnification)

D.43 Charred stem 'type C' cross-section showing hollow interior typical of grasses (45X magnification)

Stem 'type D'

D.44 Charred stem 'type D' (2 views) characterized by a sturdy structure which snaps cleanly (2 views)



D.45 Stem "type D" is hollow with highly light-reflective surface flecking (45X magnification)

Wild plants
Dicotyledonae (Dicotyledons)

Amaranthaceae (Amaranth Family)
Amaranthus-type (pigweed)(compare with Chenopodium, images B.60 and B.61)

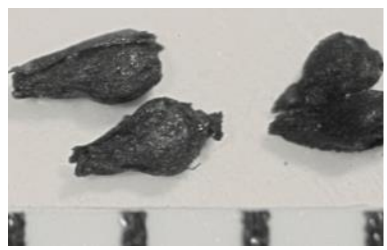
D.46 Charred *Amaranthus*-type seed (40X magnification). The encircling rim is separating from the seed.

D.47 Uncharred modern *Amaranthus* and *Chenopodium* (one specimen lower left). *Amaranthus* has a thin and obvious rim and smooth shiny seedcoat (10X magnification) Specimens from author's comparative collection.

Asteraceae (Aster/Sunflower Family)
***Artemisia tridentata*-type (big sagebrush)**

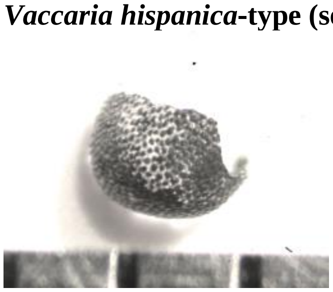
D.48 Charred *Artemisia tridentata*-type flowering heads (7X magnification)(2 views).

D.49 Charred *Artemisia tridentata*-type flowering heads (20X magnification).

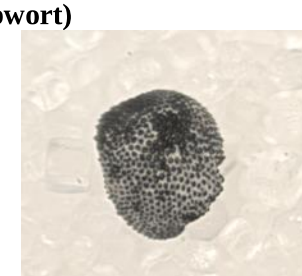


D.50 Charred *Artemisia tridentata*-type achenes (30X).

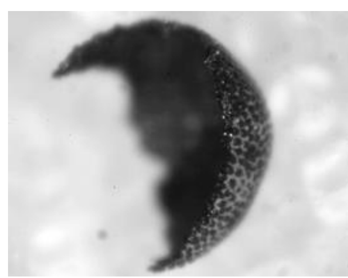
Caryophyllaceae (Pink Family)
***Vaccaria hispanica*-type (soapwort)**



D.51 Charred (?) *Vaccaria hispanica*-type seedcoat (3 views) recovered in sample SC9 midden.



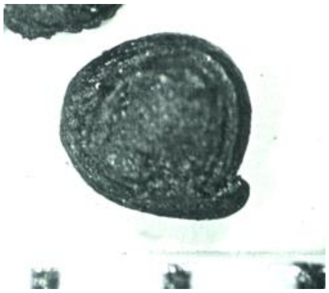
D.52 Charred (?) *Vaccaria hispanica*-type seedcoat with typical dimpled (muricate) surface morphology.



D.53 Charred (?) *Vaccaria hispanica*-type fragile and thin seedcoat side view (45X magnification).

Wild plants
Dicotyledonae (Dicotyledons)

Chenopodiaceae (Goosefoot Family)
Various



D. 54 Charred *Atriplex canescens*-type (four-wing saltbush) achene showing a ringlike embryo and protruding radicle tip (25X magnification)

D.55 Charred *Chenopodium*-type seed (40X magnification, computer enlarged). This specimen shows the rounded margin without a rim and stippled seedcoat.

D.56 Ancient (cf) cheno-am-type seed coats showing some of the orange staining suggestive of ancient specimens. Black specimens are presumed charred (7X magnification)

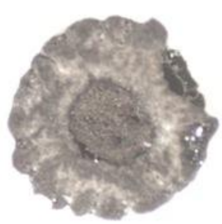
Dicotyledon-type miscellaneous

D.57 Dicotyledon leaves (*Artemisia tridentata*- [far left] and *Purshia tridentata*-types [far right]) (7X magnification)

D.58 Simple dicotyledon leaves with orange staining suggestive of ancient preservation (7X magnification)

Malvaceae (Mallow Family)
Sand Canyon "Malva"-type

D.59 Charred "*Malva"*-type fruit schizocarp, ventral view showing segments (25X magnification)



D.60 Charred "*Malva*"-type fruit schizocarp, ventral view showing large depression in the center typical of *Malva* species (45X magnification, computer enlarged)

D.61 Charred "*Malva*"-type fruit schizocarp, dorsal view showing small peltate stalk attachment (45X magnification, computer enlarged)

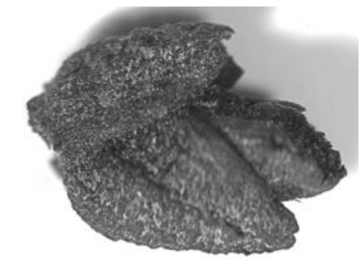
Wild plants
Dicotyledonae (Dicotyledons)

Rosaceae (Rose Family)
***Amelanchier utahensis*-type (Utah serviceberry)**

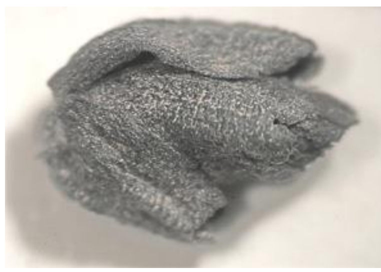
D.62 Modern uncharred *Amelanchier utahensis* twig and terminal bud at a later stage of development (author's comparative collection)(20X magnification)

D.63 Charred Sand Canyon Pueblo *Amelanchier utahensis*-type twig and terminal bud, total length 5 mm (20X magnification)

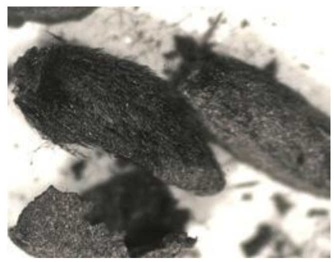
D.64 Charred Sand Canyon Pueblo *Amelanchier utahensis*-type buds (20X magnification)



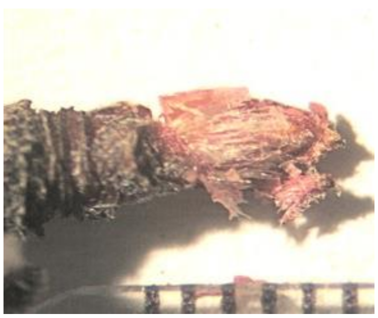
D.65 Charred Sand Canyon Pueblo *Amelanchier utahensis*-type bud (45X magnification)



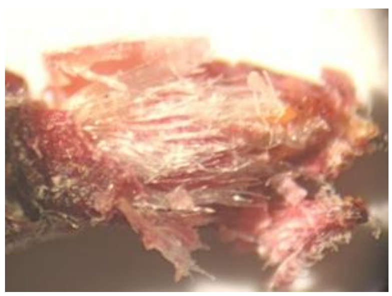
D.66 Charred Sand Canyon Pueblo *Amelanchier utahensis*-type bud (45X magnification)



D.67 (D.66 specimen broken open to reveal internal structure at 15X magnification)



D.68 Modern uncharred *Amelanchier utahensis* twig with outer bracts removed from terminal bud (author's comparative collection)(15X magnification)



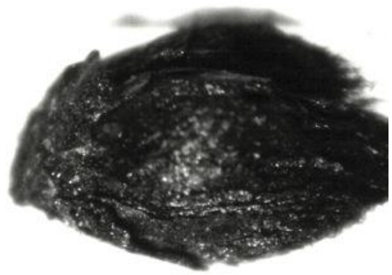
D.69 Modern uncharred *Amelanchier utahensis* bud with outer bracts removed showing abundance hair-like structures (author's comparative collection)(20X magnification)

D.70 Charred Sand Canyon Pueblo *Amelanchier utahensis* twig with terminal bud missing outer bracts and hair-like structures (20X magnification, enlarged)

Wild plants
Dicotyledonae (Dicotyledons)

Rosaceae (Rose Family)
***Amelanchier utahensis*-type (Utah serviceberry)**

D.71 Charred Sand Canyon Pueblo *Amelanchier utahensis*-type terminal buds with missing hard bracts showing abundant hair-like structures (20X magnification)



D.72 Charred Sand Canyon Pueblo *Amelanchier utahensis*-type terminal buds with missing hard bracts and showing abundant hair-like structures (45X magnification)

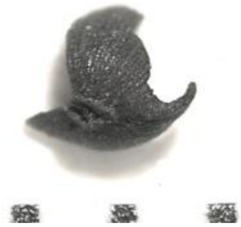
Solanaceae (Potato/Nightshade Family)
***Physalis longifolia* (Common/longleaf groundcherry)**

D.73 Charred and uncharred *Physalis longifolia*-type seeds from midden sample FV14. Uncharred seeds have orange stain suggesting ancient specimens and excellent preservation

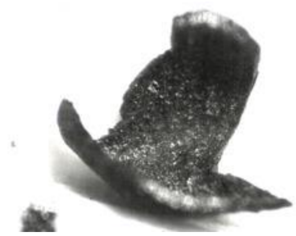
Unknown botanical
Unknown reproductive parts

Seeds, achenes and caryopses

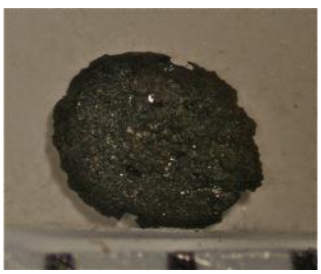
D.74 Uncharred possibly ancient seed compares fairly well to *Alyssum minus* (L.) Roth (Alyssum/madwort) (CCAC Herbarium Collection). Similarities include size, ovoid shape and papery wings (15X magnification).



D.75 Charred *Brassica*-like seedcoat (2 views)(20X magnification, computer enlarged). Not the parallel striations and hilum.



D.76 (D.75 interior view. Note the heavy seedcoat at 40X magnification).



D.77 Tentatively identified as a *Corispermum*-like achene (charred), showing degraded seedcoat, fragmentation suggestive of remnants of papery wings. Length approximately 2 mm (20X magnification, computer enlarged).

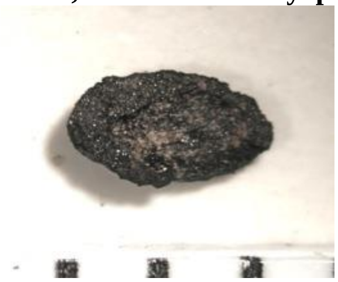
D.78 Opposite side of image B.80 that appears to show the achene core. Tentatively identified as a *Corispermum*-like achene (20X magnification, computer enlarged).

D.79 Uncharred *Croton*-like seed (immature?)(25X magnification) recovered in a sample (SC6) midden.

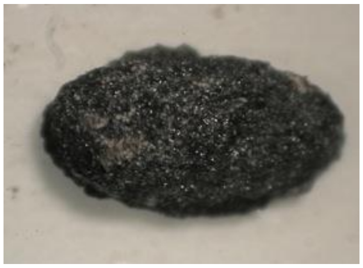
D.80 Charred degraded triangular/ biconvex seed (see image B.86 for opposite view) reminiscent of *Opuntia* (2 views) (10X magnification, computer enlarged).

Unknown botanical
Unknown reproductive parts

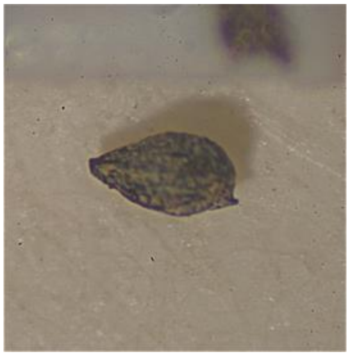
Seeds, achenes and caryopses



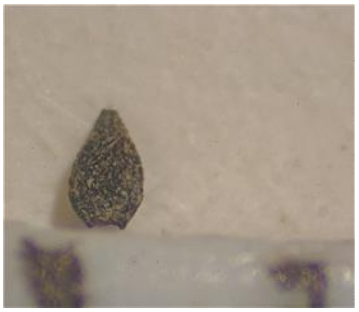
D.81 Charred *Plantago*-like seed (15X magnification, computer enlarged)(two views).



D.82 D.81 enlarged (35X magnification, computer enlarged) recovered in sample FV14 from block 1200 midden.

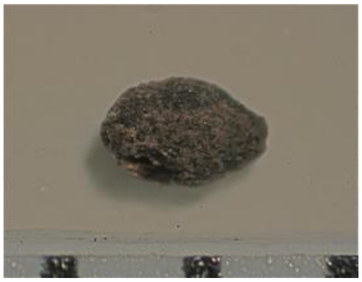


D.83 Charred, minute (approximately .25 mm) tentatively identified as a Poaceae caryopsis, unknown festucoideae-type, side view (30X magnification, computer enlarged).

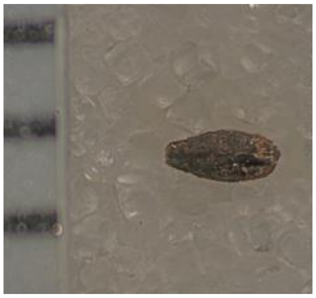


D.84 Specimen D.83 showing size (45X magnification).

D.85 Specimen D.83 showing what appears to be an embryo depression.



D.86 Degraded Poaceae caryopsis (cf), unknown type, embryo depression is not seen (30X magnification, computer enlarged).

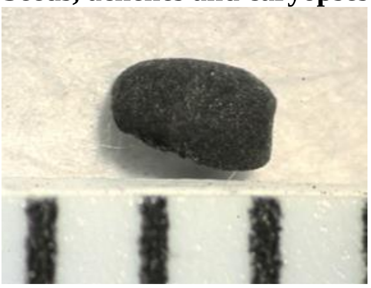


D.87 Specimen D.86 side view (20X magnification, computer enlarged).

D.88 Degraded Poaceae caryopsis. Shows venation under the microscope, but not clear in photography. This specimen is shown at 15X magnification (computer enlarged).

Unknown botanical
Unknown reproductive parts

Seeds, achenes and caryopses



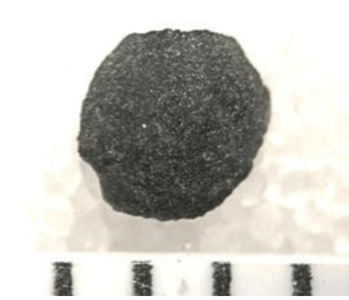
D.89 Charred unknown seedcoat half, tentatively identified as *Sisymbrium/Thelypodiopsis*-type (25X magnification)(2 views) recovered in sample FV7 from a kiva hearth.

D.90 Charred unknown seedcoat half (D.90) interior view. Note the thickness of the seedcoat (45X magnification, computer enlarged).

D.91 Uncharred unknown, immature round seeds (30X magnification, computer enlarged) recovered in a sample (SC6) midden.

D.92 Charred unknown elliptical seed recovered in a sample (FV14) from the block 1200 midden (40X magnification, computer enlarged).

D.93 Specimen B.92 showing two slight protruberances (opposite view)(40X magnification).

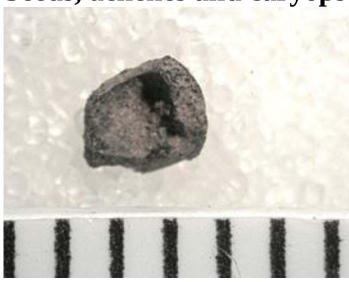


D.94 Charred plano-convex seed(?)(2 views)(20X magnification, computer enlarged).

D.95 D.94 enlarged (20X magnification, computer enlarged), recovered from sample FV14, block 1200 midden.

Unknown botanical
Unknown reproductive parts

Seeds, achenes and caryopses



D.96 Charred unknown thick nutshell-like fragment (2 views)(15X magnification).

D.97 Unknown nutshell-like fragment, dorsal view (25X magnification, computer enlarged), from sample FV18, D-shaped building trash accumulation.

Buds, unknown

D.98 Bud type 1 (15X magnification, computer enlarged).

D.99 Bud type 1 (25X magnification, computer enlarged).

D.100 Bud type 2 (7X magnification).

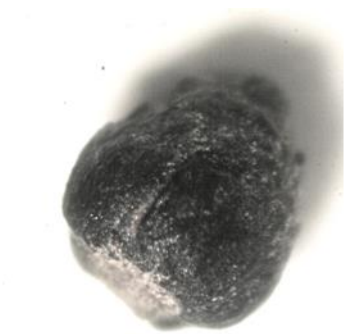
D.101 Bud type 2 (20X magnification, computer enlarged).

Unknown botanical
Unknown reproductive parts

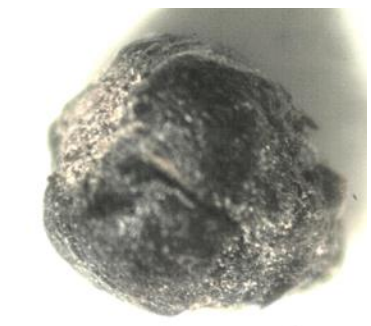
Buds, unknown

D.102 Bud type 3 (7X magnification, photo enlarged).

D.103 Bud type 3 (15X magnification, photo enlarged).



D.104 Bud type 4 (25X magnification, photo enlarged).



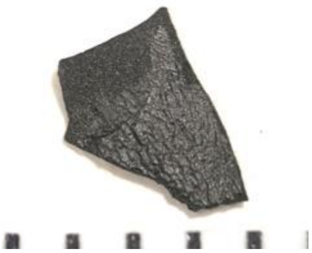
D.105 Bud type 4 (30X magnification, photo enlarged).

D.106 Bud type 5 (15X magnification, photo enlarged).

D.107 Bud type 5 (30X magnification, photo enlarged).

Unknown botanical
Unknown tissue

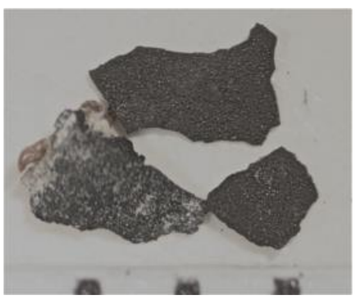
Tissues, assorted



D.108 Charred monocotyledon-type rind with rugulose surface texture (7X magnification).

D.109 Surface characteristics of specimen D.108 (40X magnification photo enlarged).

D.110 Charred tissue fragment showing conspicuous rugulose surface pattern (30X magnification, photo enlarged).

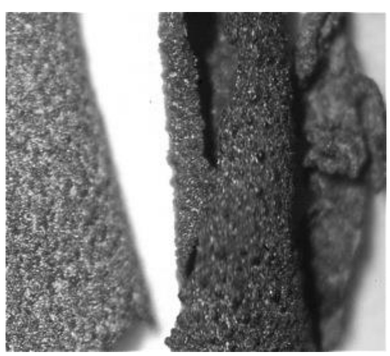


D.111 Unknown charred tissues with nodoulose-type surface (20X magnification).

D.112 Unknown charred tissues with nodulose surfaces (35X magnification, photo enlarged).

D.113 Charred *Yucca baccata*-type tissue fragments that compare well with modern comparative samples (7X magnification).

D.114 Unknown charred Sand Canyon Pueblo tissues, papillose surface. Resembles *Yucca baccata* comparative leaf fragments (CCAC Herbarium Collection)(7X magnification).

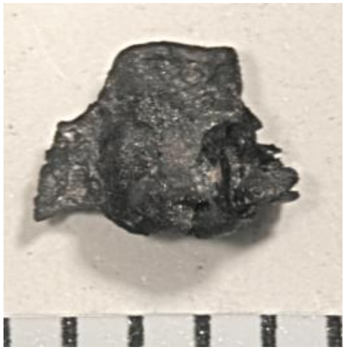


D.115 Unknown charred Sand Canyon Pueblo tissues, papillose surface. Compares favourably to *Yucca baccata* leaf fragments (15X magnification, photo enlarged).

D.116 *Yucca baccata* leaf fragments photographed from the CCAC Herbarium Collection, July 2009.

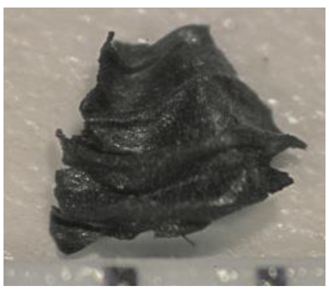
Unknown botanical
Unknown tissue

Miscellaneous

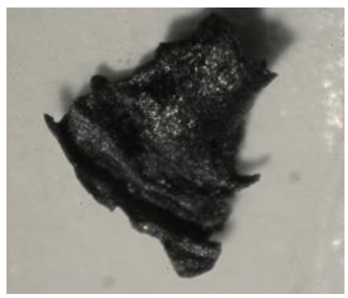


D.117 Charred tissue type 1 (2 views - side 1)(15X magnification).

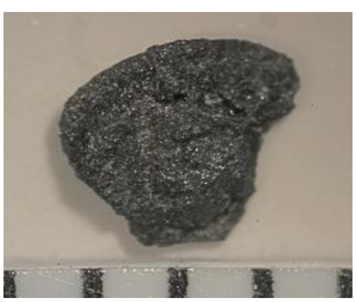
D.118 Charred tissue type 1 (side 2)(15X magnification).



D.119 Charred tissue type 2 (two views)(30X magnification), FV14 midden sample.



D.120 Charred tissue type 2, opposite view (35X magnification) FV14 midden sample.

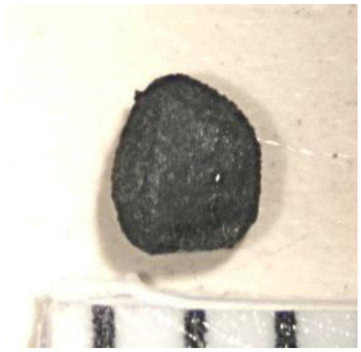


D.121 Charred tissue type 3 (two views)(35X magnification), FV14 midden sample.

D.122 Charred tissue type 3, opposite view (40X magnification), FV14 midden sample.

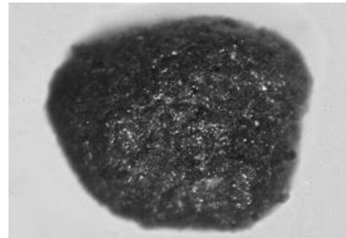
Unknown botanical
Unknown tissue

Miscellaneous



D.123 Charred tissue type 4 (2 views)(7X magnification), FV14 midden sample.

D.124 Charred tissue type 4 (opposite view)(20X magnification, photo enlarged).

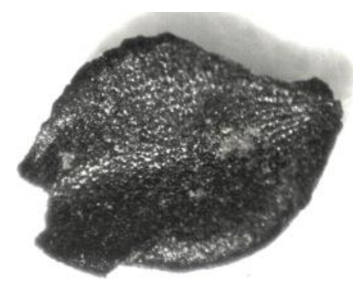


D.125 Charred tissue type 4 (opposite view)(30X magnification, photo enlarged).

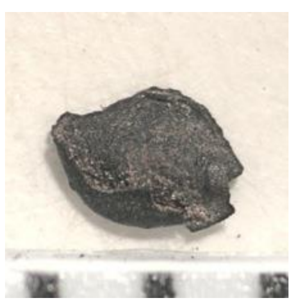
D.126 Charred tissue type 5 (3 views). Compares favourably to experimentally charred Chapalote maize kernel epidermis (7X magnification).

D.127 Charred tissue type 5 (35X magnification).

D.128 Charred tissue type 5 (45X magnification).



D.129 Charred tissue type 6 (2 views)(35X magnification, photo enlarged)

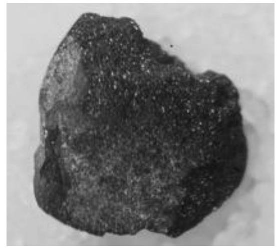


D.130 Charred tissue type 6 (opposite view)(35X magnification).

Unknown botanical
Unknown Tissue

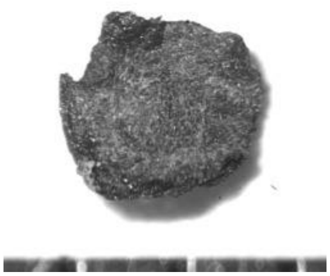
Miscellaneous

D.131 Charred tissue "type 7" (7X magnification)(three views).



D.132 Charred tissue "type 7" (10X magnification).

D.133 Charred unknown tissue "type 7" (7X magnification).



D.134 Charred unknown tissue "type 8" (15X magnification)(2 views, D.140, surface 1).

D.135 Charred unknown tissue "type 8" (20X magnification, computer enlarged)(surface 2).

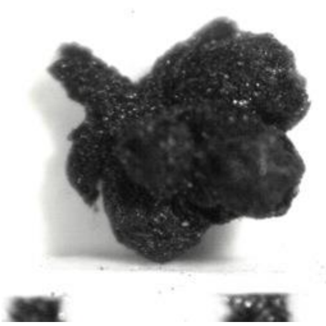
Unknown Botanical
Miscellaneous

Other

D.136 Charred flowering heads similar to *Rhus*-type (Sumac). No other evidence of this genus recovered in 2009.

D.137 Charred unknown, similar to the general description of "Type 2 Unknown" from Duckfoot site (Adams 1993:209; described in Adams and Murray 2004)(10X magnification)(two views).

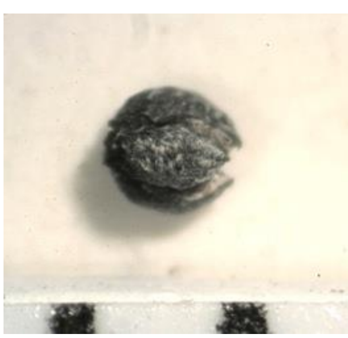
D.138 Tentatively labelled "Type 2 Unknown" (as per Adams 1993:209; Adams and Murray 2004)(D.137 20X magnification). Secondary refuse accumulation, D-shaped building room.



D.139 Charred unknown bud? (45X magnification, photo enlarged).

D.140 Charred twig with buds or developing cones (45X magnification, photo enlarged).

D.141 Charred twig with leaves or buds (45X magnification.)



D.142 Charred minute bud (45X magnification).

D. 143 Charred, slightly compressed-ovate "unknown" with stalk (45X magnification) (two views).

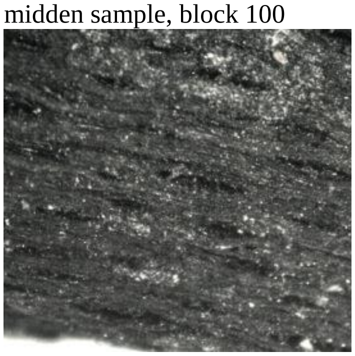
D.144 Image D.149. Original size less than 1 mm (45X magnification, photo enlarged).

Botanical

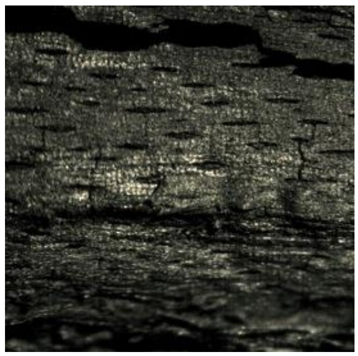
Miscellaneous, Other

D.145
Uncharred, presumed ancient "white spherical body" (35X magnification)(2 views), midden sample, block 100

D.146
Uncharred, presumed ancient "white spherical body," image D.145 enlarged

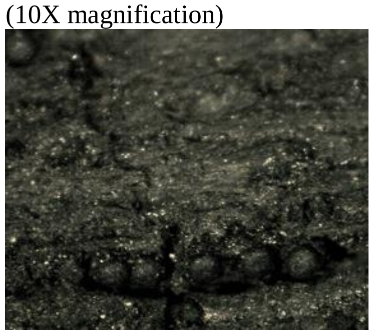


D.147
Charred wood with lenticular surface. Compares well with *Artemisia tridentata*-type woods



D.148
Experimentally charred modern *Artemisia tridentata* wood showing surface with lenticels (10X magnification)

D.149
Experimentally charred modern *Chrysothamnus nauseosus* bark with lenticels and nodules (10X magnification)(2 views)

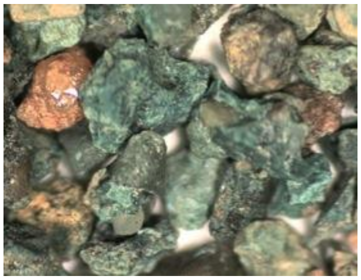


D.150
Experimentally charred modern *Chrysothamnus nauseosus* bark (30X magnification)(D.149 enlarged) showing strings of nodules

Nonbotanical remains

Mineral

D.151
Uncharred *Ferrian Illite/Glauconite* grains, both angular and rounded (3 views).



D.152
Uncharred *Ferrian Illite/Glauconite* grains (enlarged).

D.153
Uncharred *Ferrian Illite/Glauconite* grains (enlarged).

Invertebrate/Beetle (Coleoptera)

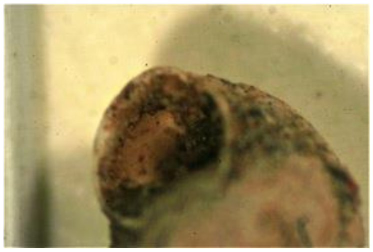
D. 154
Charred insect remains. Elytra (forewings) are typical of *Harpalus*-type beetles and are not associated with the large body part in the center of the image.

D.155
Image B.160 enlarged. There are approximately 350,000 different species of beetle, the identification of *Harpalus*-type is associated with the wings (upper frame) and not confirmed. Body is a different insect.

Mollusca/Gastropoda (Gastropod)

D.156
Uncharred possibly ancient land snail (*Pupoides*-type)(15X magnification). Distinguished by the configuration of the aperture.

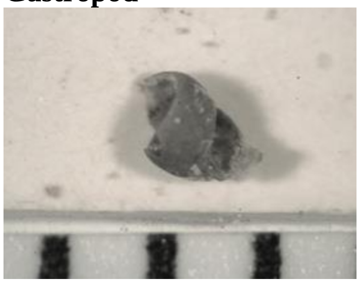
D.157
Image D.156 (25X magnification) computer enlarged. Aperture not visible. Size approximately 2-3 mm in length, 1 mm diameter.



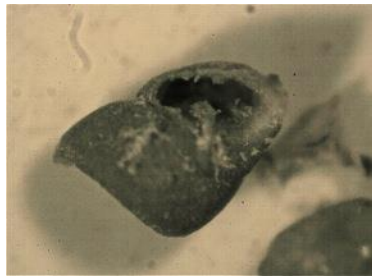
D.158
Pupoides-type land snail showing diagnostic aperture (45X magnification).

Nonbotanical remains continued

Gastropod



D.159
Uncharred land snail fragment (*Vertigo*-type)(35X magnification), distinguished by the configuration of the aperature



D.160
Enlarged view of image D.159 aperature (45X magnification).

Appendix E: Bulk volume comparison, Sand Canyon Pueblo samples

Interpretative categories are described in chapter 8, Table 8.1, pp. 238-239

Table E.1 Burned spot comparison 1: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] (CV1) 1a	1b	1c	Vol.2[c] FV1
Charred botanical and nonbotanical remains							
Domesticated plants							
Zea mays	maize, corn	cupule	FLZ	-	-	1	-
Zea mays	maize, corn	kernel fragment	FD	-	-	-	1
Wild plants							
Gymnosperms							
Gymnosperm-type	softwood	charcoal	-	-	-	-	2
Juniperus-type	juniper	charcoal	FLN	12	7	17	16
Pinus edulis-type	pinyon pine	charcoal	FLN	-	-	-	2
Pinus-type	pine	bark scale	FLT	1	6	1	7
Pinus-type	pine	charcoal	FLN	1	5	1	-
Angiosperms							
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	pome	FO/OE	1	-	-	-
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	-	2	1
Angiosperm-type (lenticular surface)		charcoal	-	-	-	-	>3
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	2	-	4
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	-	-	23
Cheno-am *(Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	-	-	2	1
Opuntia (prickly pear)-type	prickly pear cactus	seed fragment	FN/OE?[d]	-	-	-	>1
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	6	-	-
Unknown botanical							
Disseminule			-	-	-	-	1
Twig			-	-	-	-	>1
Nonbotanical							
Black spherical body			-	-	-	-	1
Fecal pellet	insect unknown		-	-	-	-	1
Fecal pellet	termite		OE	-	-	1	-
Uncharred botanical and nonbotanical remains							
Unknown botanical							
Disseminule			-	-	-	-	>10
Twig			-	-	-	-	>1
Nonbotanical							
Insect part			-	-	-	-	3

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from feature 2 (PD 729, FS 1), feature 5 (PD 732, FS 1), and feature 7 (PD 737, FS1)(CCAC 2015a).

[c] Volume 2 results based on data from feature 1 (PD 728, FS 1)(this author).

[d] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of harvest must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.

Table E.2 Burned spot comparison 2: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV2	Vol. 2[c] FV2
Charred botanical and nonbotanical remains					
Domesticated plants					
Zea mays	maize, corn	kernel	FD	1	-
Zea mays	maize, corn	kernel embryo	FD	1	-
Wild plants					
Gymnosperms					
Juniperus-type	juniper	charcoal	FLN	-	13
Pinus edulis-type	pinyon pine	cone, umbos	FLT	-	2
Pinus edulis-type	pinyon pine	charcoal	FLN	-	2
Pinus-type	pine	bark scale	FLT	-	14
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	twig	FLT	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	4
Angiosperm	unknown	charcoal	-	-	1
Artemisia tridentata-type	big sagebrush	twig	FLT	-	1
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	15
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	1
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	4	-
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	3
Diffuse porous-type		charcoal	-	-	1
Physalis longifolia-type	common groundcherry	seed	FW/OE	3	1
Portulaca retusa-type	purslane	seed	FW/OE	1	-
Quercus-type	oak	charcoal	FLS	-	1
Salix-type (cf)	willow	charcoal	FLS	-	1
Semi-ring porous-type		charcoal	-	-	1
Stipa/Oryzopsis hymenoides-type	Indian ricegrass	floret, caryopsis	FW/OE	-	21
Unknown botanical					
Bud			-	1	-
Seed fragment			-	-	1
Nonbotanical					
Hair/filament			-	-	1
Uncharred botanical and nonbotanical remains					
Wild plants					
Gymnosperms					
Pinus edulis-type	pinyon pine	needle fragment	-	-	1
Angiosperms					
Poaceae-type	grass	floret	-	-	>1
ɔhaeralcea-type	globemallow	seed	-	-	1
Unknown botanical					
Disseminule			-	-	>6
Nonbotanical					
Fecal pellet (insect unknown)			-	-	>3
Fiber (blue), modern			-	-	>1
Insect casing			-	-	2
Insect part			-	-	4

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b.] Volume 1 results based on data from PD 856, FS 1(CCAC 2015a).

[c…] Volume 2 results based on data from PD 816, FS 1(this author).

Table E.3 Firepit comparison 1: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol.1[b] CV3	Vol. 2[c] FV3
Charred botanical and nonbotanical remains					
Domesticated plants					
Zea mays	maize, corn	cupule	FLZ	5	1
Wild plants					
Gymnosperms					
Gymnosperm-type		charcoal	-	-	1
Juniperus-type	juniper	charcoal	FLN	7	18
Pinus-type	pine	bark scale	FLT	-	14
Pinus-type	pine	charcoal	FLN	3	4
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	1	-
Physalis longifolia-type	common groundcherry	seed	FW/OE	4	-
Portulaca retusa-type	purslane	seed	FW/OE	-	1
Unknown botanical					
Disseminule			-	-	1
Tissue (unknown)			-	-	3
Tissue (vitrified)			-	-	3
Nonbotanical					
Black spherical body			-	-	1
Uncharred botanical & nonbotanical remains					
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	3
Juniperus osteosperma-type	Utah juniper	twig	-	-	2
Pinus contorta-type	lodgepole pine	needle fragment	-	-	1
Pinus edulis-type	pinyon pine	needle fragment	-	-	1
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	-	-	4
Poaceae-type	grass family	floret	-	-	2
Unknown Botanical					
Disseminule			-	-	>10
Twig			-	-	>1
Nonbotanical					
Fecal pellet (insect unknown)			-	-	>9
Insect part			-	-	10

Notes:
[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.
[b] Volume 1 results based on data from PD 849, FS 1 (CCAC 2015a).
[c] Volume 2 results based on data from PD 849, FS 2 (this author).

Table E.4 Firepit comparison 2: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV4	Vol. 2[c] FV4
		Charred botanical and nonbotanical remains			
Domesticated plants					
Zea mays	maize, corn	cupule	FLZ	-	1
Zea mays	maize, corn	kernel	FD	-	4
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	5	5
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	3
Juniperus-type	juniper	cone	FLT	-	1
Juniperus-type	juniper	charcoal	FLN	10	13
Pinus edulis-type	pinyon pine	needle fragment	FLT	-	1
Pinus edulis-type	pinyon pine	charcoal	FLN	-	2
Pinus-type	pine	bark scale	FLT	24	>20
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	1
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	3
Atriplex-type	saltbush	charcoal	FLS	-	3
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	2
Fraxinus-type‡	ash	charcoal	FLS	1	-
Physalis longifolia-type	common groundcherry	seed	FW/OE	1	-
Poaceae (festucoid-type)	grass family	caryopsis	FW	-	1
Poaceae (type B)	grass family	stem fragment	OU	-	1
Prunus/Rosa-type‡	chokecherry/rose	charcoal	FLS	1	-
Purshia tridentata-type	bitterbrush	leaf	OU	-	1
Unknown botanical					
Leaf			-	-	1
Tissue (epidermis)			-	-	1
Tissue (unknown)			-	-	>12
Unknown			-	-	1
Nonbotanical					
Fecal pellet (insect unknown)			-	-	1
		Uncharred botanical and nonbotanical remains			
Wild plants					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	2
Juniperus osteosperma-type	Utah juniper	twig	-	-	1
Unknown botanical					
Disseminule			-	-	>7
Nonbotanical					
Fecal pellet (insect unknown)			-	-	1

Notes:

[a]…"Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b]…Volume 1 results based on data from PD 847, FS2 (CCAC 2015a).

[c] Volume 2 results based on data from PD 847, FS 1 (this author).

‡ Identification noted as "questionable."

Table E.5 Firepit comparison 3: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV5	Vol. 2[c] FV5
Charred botanical and nonbotanical remains					
Domesticated plants					
Zea mays	maize, corn	cob fragment	FLZ	4	-
Zea mays	maize, corn	cupule	FLZ	20	-
Zea mays	maize, corn	kernel	FD	1	6
Zea mays	maize, corn	kernel embryo	FD	-	1
Zea mays	maize, corn	kernel fragment	FD	2	-
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	1
Juniperus-type	juniper	cone	FLT	-	1
Juniperus-type	juniper	charcoal	FLN	10	16
Pinus-type	pine	bark scale	FLT	1	2
Angiosperms					
Amaranthus-type	pigweed	seed	FW/OE	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	1
Angiosperm-type (lenticular surface)		charcoal	-	-	>4
Artemisia/A. tridentata-type	big sagebrush	achene	FO/OE	-	2
Artemisia tridentata-type	big sagebrush	flowering head	OU/OE	-	8
Artemisia tridentata-type	big sagebrush	leaf	OU	-	4
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	4
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	1
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	4	1
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	3
Monocotyledon-type		leaf	OU	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed/seed fragments	FN/OE?[d]	4	>28
Physalis longifolia-type	common groundcherry	seed	FW/OE	2	-
Physalis longifolia-type	common groundcherry	seedcoat	FW/OE	-	1
Polanisia-type	clammy-weed	seedcoat	FN/OE?[e]	-	1
Polygonum-type	bindweed	achene	FN/OE?[e]	-	1
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	10	-
Purshia tridentata-type	bitterbrush	leaf	OU	-	2
Yucca baccata-type	datil yucca	seed	FN/OE	1	-
Unknown botanical					
Disseminule			-	-	1
Flowering head			-	-	2
Leaf			-	-	2
Seedcoat			-	-	1
Tissue (type 7)			-	-	1
Tissue (type 8)			-	-	1
Tissue (unknown)			-	-	>3
Twig			-	1	-
Unknown			-	-	1
Uncharred botanical and nonbotanical remains					
Wild plants					
Artemisia tridentata-type	big sagebrush	achene	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	embryo	-	-	9
Opuntia (prickly pear)-type	prickly pear cactus	seed	-	3	>16
Physalis longifolia-type	common groundcherry	seed	-	-	7
Unknown botanical					
Disseminule			-	-	>9

continued...

Table E.5 Firepit comparison 3: recovered archaeological remains, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV5	Vol. 2[c] FV5
		Uncharred botanical and nonbotanical remains			
Nonbotanical					
Bone			-	-	1
Fecal pellet (insect unknown)			-	-	6
Fecal pellet (termite)			OE	-	1
Insect part			-	-	5

Notes:
[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.
[b] Volume 1 based on data from PD 874, FS 5 (CCAC 2015a).
[c] Volume 2 based on data from PD 875, FS 2 (this author).
[d] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of harvest must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.
[e] No seasonality information found for SCP area.

Table E.6 Hearth comparison 1: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV6	Vol. 2[c] FV6
		Charred botanical and nonbotanical remains			
Domesticated plants					
None recovered			-	-	-
Wild plants					
Juniperus-type	juniper	charcoal	FLN	12	4
Pinus-type	pine	bark scale	FLT	3	2
Pinus-type	pine	charcoal	FLN	-	2
Unknown botanical					
Tissue (vitrified)			-	-	4
Twig			-	-	>3
Nonbotanical					
Bone			-	-	1
		Uncharred botanical and nonbotanical remains			
Domesticated plants					
None recovered			-	-	-
Wild plants					
Juniperus osteosperma-type	Utah juniper	twig	-	-	3
Unknown botanical					
Disseminule			-	-	>7
Twig			-	-	>9
Nonbotanical					
Fecal pellet (insect unknown)			-	-	1

Notes:
[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.
[b] Volume 1 results based on data from PD 1454, FS 10 (CCAC 2015a).
[c] Volume 2 results based on data from PD 1454, FS 9 (this author).

Table E.7 Hearth comparison 2: recovered archaeological remains.

Taxon/Occurrence[a]	**Common name**	**Part**	**Interpretative category**	**Vol. 1**[b] **CV7**	Vol. 2[c] FV7
		Charred botanical and nonbotanical remains			
Domesticated plants					
Cucurbita-type	gourd/squash	seed fragment	FD	1	-
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	1
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	2
Juniperus-type	juniper	charcoal	FLN	15	16
Pinus edulis-type	pinyon pine	charcoal	FLN	-	2
Pinus-type	pine	bark scale	FLT	3	5
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	5	-
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	3
Opuntia (prickly pear)-type	prickly pear cactus	seed fragment	FN/OE?[d]	2	-
Physalis longifolia-type	common groundcherry	seed	FW/OE	4	-
Unknown botanical					
Bud			-	-	2
Seed			-	1	-
Seedcoat (tentative identification) (*Sisymbrium/Thelyodiopsis)*(cf)[e]	tumblemustard-like		OU	-	1
Tissue (unknown)			-	-	1
Nonbotanical					
None noted			-	-	-
		Uncharred botanical and nonbotanical remains			
Wild plants					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	1
Juniperus-type	juniper	cone scale	-	-	1
Unknown botanical					
Disseminule			-	-	>5
Twig			-	-	>1
Nonbotanical					
Bone			-	1	-
Fecal pellet (insect unknown)			-	-	>3

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 1482, FS 4 (CCAC 2015a).

[c] Volume 2 results based on data from PD 1481, FS 3 (this author).

[d] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of harvest must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.

[e] Compares favourably.

Table E.8 Hearth comparison 3: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV8	Vol. 2[c] FV8
		Charred botanical and nonbotanical remains			
Domesticated plants					
Zea mays	maize, corn	cupule	FLZ	1	-
Wild plants					
Gymnosperms					
Gymnosperm	unknown type	charcoal	-	-	1
Juniperus-type	juniper	charcoal	FLN	3	2
Pinus edulis-type	pinyon pine	charcoal	FLN	-	7
Angiosperms					
Opuntia (prickly pear)-type	prickly pear cactus	seed	FN/OE?[d]	2	-
Unknown botanical					
Bud			-	-	1
		Uncharred botanical and nonbotanical remains			
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	1
Pinus edulis-type	pinyon pine	needle fragment	-	-	1
Angiosperms					
Artemisia tridentata-type	big sagebrush	leaf	-	-	1
Cheno-am *(Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	-	-	1
Poaceae-type	grass	floret	-	-	2
Unknown botanical					
Disseminule			-	-	>5
Twig			-	-	>2
Nonbotanical					
Bone			-	1	1
Fecal pellet (insect unknown)			-	-	>3
Gastropod (*Pupoides* sp.)			OU/OE	-	1
Insect casing			-	-	1

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 1531, FS 2 (CCAC 2015a).

[c] Volume 2 results based on data from PD 1530, FS 2 (this author).

[d] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of harvest must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.

Table E.9 Hearth comparison 4: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV9	Vol. 2[c] FV9
Charred botanical and nonbotanical remains					
Domesticated plants					
None recovered			-	-	-
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	18
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	5
Juniperus-type	juniper	charcoal	FLN	3	13
Pinus-type	pine	bark scale	FLT	-	1
Angiosperms					
Amaranthus-type	pigweed	seed	FW/OE	-	1
Chenopodium-type	goosefoot	seed	FW/OE	-	1
Stipa/Oryzopsis hymenoides-type	Indian ricegrass	floret/caryopsis	FW/OE	-	1
Unknown botanical					
Bud			-	4	3
Twig			-	-	1
Nonbotanical					
Insect part			-	-	1
Uncharred botanical and nonbotanical remains					
Domesticated plants					
None recovered			-	-	-
Wild plants					
Juniperus osteosperma-type	Utah juniper	twig	-	-	1
Unknown botanical					
Disseminule			-	-	>5
Twig			-	-	1
Nonbotanical					
Fecal pellet (insect unknown)			-	-	>4
Insect part			-	-	>3

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 1432, FS 13 (CCAC 2015a).

[c] Volume 2 results based on data from PD 1432, FS 14 (this author).

Table E.10 Hearth comparison 5: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV10	Vol. 2[c] FV10
Charred botanical and nonbotanical remains					
Domesticates					
None recovered			-	-	-
Wild plants					
Gymnosperms					
Juniperus-type	juniper	charcoal	FLN	-	18
Pinus-type	pine	bark scale	FLT	-	3
Pinus-type	pine	charcoal	FLN	-	1
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	4
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	1
Juncus-type	rush	achene/seed	OE/OU	-	1
Semi ring porous-type		charcoal	-	-	9
Unknown botanical					
Bud			-	-	1
Rind fragment			OU	-	8
Tissue (unknown)			-	-	4
Tissue (vitrified)			-	-	31
Nonbotanical					
None recovered			-	-	-
Uncharred botanical and nonbotanical remains					
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	-	-	1
Angiosperms					
Poaceae-type	grass family	stem segment	-	-	1
Unknown botanical					
Disseminule			-	-	>10
Twig			-	-	>3
Nonbotanical					
Fecal pellet (insect unknown)			-	-	>11
Insect part			-	-	>4

Notes:

[a] “Occurrence” accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 244, FS 1, no botanical remains were recovered (CCAC 2015a).

[c] Volume 2 results based on data from PD 243, FS 5 (this author).

Table E. 11 Midden comparison 1: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	CV11a	Vol. 1[b] CV11b	Vol. 2[c] FV11
			Charred botanical and nonbotanical remains			
Domesticated plants						
Zea mays	maize, corn	cob fragment	FLZ	-	3	11
Zea mays	maize, corn	cob segment	FLZ	-	-	2
Zea mays	maize, corn	cupule	FLZ	-	2	20
Zea mays	maize, corn	kernel fragment	FD	1	-	2
Wild plants						
Gymnosperms						
Juniperus-type	juniper	charcoal	FLN	12	11	16
Pinus edulis-type	pinyon pine	needle fragment	FLT	-	-	1
Pinus edulis-type	pinyon pine	charcoal	FLN	-	-	8
Pinus-type	pine	bark scale	FLT	3	4	19
Pinus-type	pine	charcoal	FLN	2	4	-
Angiosperms						
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	1	-	2
Artemisia tridentata-type	big sagebrush	charcoal	FLS	2	1	5
Artemisia tridentata-type	big sagebrush	twig	FLT	-	-	1
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	1	-
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	-	4
Diffuse porous-type		charcoal	-	4	-	-
Populus/Salix-type	cottonwood/willow	charcoal	FLS	-	1	-
Quercus-type	oak	charcoal	FLS	1	-	-
Semi ring porous-type		charcoal	-	-	-	1
Unknown botanical						
Fruit top			OU	-	-	1
Tissue (unknown)			-	-	-	>1
Nonbotanical						
Black spherical body			-	-	-	5
Fecal pellet (insect unknown)			-	-	-	>2
			Uncharred botanical and nonbotanical remains			
Wild plants						
Gymnosperms						
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	-	>11
Juniperus osteosperma-type	Utah juniper	twig	-	-	-	>52
Juniperus-type	juniper	cone (male)	-	-	-	9
Pinus edulis-type	pinyon pine	needle fragment	-	-	-	22
Angiosperms						
Poaceae-type	grass family	floret	-	-	-	8
Portulaca retusa-type	purslane	seed	-	-	-	1
Unknown botanical						
Bud			-	-	-	3
Disseminule			-	-	-	>8
Flowering head			-	-	-	>1
Nonbotanical						
Bone			-	-	-	2
Fecal pellet (insect unknown)			-	-	-	>5
Gastropod (Pupillidedae)	*Vertigo*-type		OU/ OE	-	-	1
Insect part			-	-	-	13

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 is based on data from PD 184, FS 73 and PD 184, FS 76 (CCAC 2015a).

[c] Volume 2 is based on data from PD 184, FS 126 (this author).

Table E.12 Midden comparison 2: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV12	Vol. 2[c] FV12
Charred botanical and nonbotanical remains					
Domesticated plants					
Zea mays	maize, corn	cupule	FLZ	5	1
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	1
Juniperus-type	juniper	charcoal	FLN	14	15
Pinus edulis-type	pinyon pine	charcoal	FLN	-	4
Pinus-type	pine	bark scale	FLT	1	2
Pinus-type	pine	charcoal	FLN	5	1
Angiosperms					
Angiosperm-type (lenticular surface)		charcoal	-	-	3
Angiosperm-type		charcoal	-	-	1
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	1
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	1	2
Purshia mexicana-type	cliffrose	charcoal	FLS	-	1
Purshia tridentata-type	bitterbrush	leaf	OU	-	1
Unknown botanical					
Bud			-	1	-
Nonbotanical					
Fecal pellet (insect unknown)			-	-	1
Uncharred botanical and nonbotanical remains					
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	1
Juniperus osteosperma-type	Utah juniper	twig	-	-	7
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	-	-	1
Yucca baccata-type	Datil yucca	capsule/pod	-	-	1
Unknown botanical					
Disseminule			-	-	>7
Tissue (unknown)			-	-	>1
Nonbotanical					
Fecal pellet (insect unknown)			-	-	>4
Insect casing			-	-	>1
Insect part			-	-	>15
Mineral (unknown)			-	-	1

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 is based on data from PD 701, FS 41 (CCAC 2015a).

[c] Volume 2 is based on data from PD 701, FS 40 (this author).

Table E.13 Midden comparison 3: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	CV13a	Vol. 1[b] CV13b	Vol. 2[c] FV13
Charred botanical and nonbotanical remains						
Domesticated plants						
Cucurbita-type	gourd/squash	rind‡	FD	2	-	-
Phaseolus vulgaris-type	common bean	cotyledon	FD	-	-	1
Zea mays	maize, corn	cob fragment	FLZ	-	-	1
Zea mays	maize, corn	cupule	FLZ	8	8	2
Zea mays	maize, corn	kernel	FD	-	1	-
Wild plants						
Gymnosperms						
Juniperus-type	juniper	charcoal	FLN	4	7	20
Pinus edulis-type	pinyon pine	charcoal	FLN	-	-	8
Pinus-type	pine	bark scale	FLT	7	10	3
Pinus-type	pine	charcoal	FLN	4	2	1
Angiosperms						
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	3	1
Angiosperm-type (lenticular surface)		charcoal	-	-	-	5
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	-	10
Ceratoides lanata-type	winterfat	twig	FLT	-	-	1
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	1	1
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	FW/OE	-	-	2
Physalis longifolia-type	common groundcherry	seed	FW/OE	1	-	-
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	-	2
Unknown botanical						
Fruit rind			OU	1	1‡	-
Tissue (parenchyma)			-	-	-	1
Nonbotanical						
Black spherical body			-	-	-	>9
Fecal pellet (insect unknown)			-	-	3	2
Fecal pellet (termite)			OE	-	-	1
Uncharred botanical and nonbotanical remains						
Wild plants						
Gymnosperms						
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	-	2
Juniperus osteosperma-type	Utah juniper	twig	-	-	-	4
Pinus edulis-type	pinyon pine	needle fragment	-	-	-	3
Angiosperms						
Artemisia tridentata-type	big sagebrush	leaf	-	-	-	1
Unknown botanical						
Disseminule			-	-	-	>7
Nonbotanical						
Bone			-	1	-	-
Fecal pellet (insect unknown)			-	-	-	>7
Insect part			-	-	-	>5

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 based on data from PD 1008, FS 107 and PD 1008, FS 113 (CCAC 2015a).

[c] Volume 2 based on data from PD 1008, FS 112 (this author).

‡ Identification noted as "questionable."

Table E.14 Midden comparison 4: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV14	Vol. 2[c] FV14
		Charred botanical and nonbotanical remains			
Domesticated plants					
Cucurbita moschata-type	butternut squash	seed fragment	FD	-	6
Cucurbita pepo-type	pumpkin	seed fragment	FD	-	8
Cucurbita-type	gourd/squash	peduncle	FD/OU?[d]	-	1
Cucurbita-type	gourd/squash	rind	FD/OU?[d]	-	32
Lagenaria-type	gourd	rind	OU/OW[e]	-	8
Phaseolus vulgaris-type	common bean	cotyledon	FD	-	2
Zea mays	maize, corn	cob fragment	FLZ	50	>23
Zea mays	maize, corn	cob segment	FLZ	-	6
Zea mays	maize, corn	cupule	FLZ	10	>32
Zea mays	maize, corn	glume	FLZ	-	4
Zea mays	maize, corn	immature kernel	FD	-	2
Zea mays	maize, corn	kernel embryo	FD	-	3
Zea mays	maize, corn	kernel fragment	FD	3	>26
Wild plants					
Gymnosperms					
Ephedra-type	ephedra	cone (developing)	OE/OU	-	>1
Ephedra-type	ephedra	cone (female)	OE/OU	-	>1
Ephedra-type	ephedra	stem segment	FO	-	>94
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	>6
Juniperus osteosperma-type	Utah juniper	seed (modified/bead)	OW	-	1
Juniperus osteosperma-type	Utah juniper	twig	FLT	2	>34
Juniperus-type	juniper	bark	FLT	-	>28
Juniperus-type	juniper	charcoal	FLN	7	19
Pinus edulis-type	pinyon pine	bark fragment	FLT	-	4
Pinus edulis-type	pinyon pine	needle fragment	FLT	-	46
Pinus edulis-type	pinyon pine	twig	FLT	-	5
Pinus edulis-type	pinyon pine	charcoal	FLN	-	10
Pinus-type	pine	bark fragment	FLT	-	1
Pinus-type	pine	bark scale	FLT	1	>23
Pinus-type	pine	charcoal	FLN	2	-
Angiosperms					
Amaranthus-type	pigweed	seed	FW/OE	-	14
Amelanchier utahensis-type	Utah serviceberry	bud	OE/OU	-	>57
Amelanchier utahensis-type	Utah serviceberry	twig	FLT	-	1
Artemisia/A. tridentata-type	big sagebrush	achene	FO/OE	-	7
Artemisia tridentata-type	big sagebrush	flowering head	OE/OU	-	32
Artemisia tridentata-type	big sagebrush	flower (immature)	OE/OU	-	5
Artemisia tridentata-type	big sagebrush	leaf	FLT/OU	-	8
Artemisia tridentata-type	big sagebrush	twig	FLT	-	>9
Artemisia tridentata-type	big sagebrush	charcoal	FLS	3	1
Atriplex-type (cf)	saltbush	bract fragment	OE/OU	-	1
Atriplex-type	saltbush	seed	FO/OE	-	1
Bromus-type (Pooideae)	brome	caryopsis	FW/OE	-	1
Ceratoides lanata-type	winterfat	twig	FLT	-	6
Cercocarpus-type	mountain mahogany	bud (and twig)	FLT	-	3
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	1
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	FW/OE	13	67
Chenopodium-type	goosefoot	seed	FW/OE	-	1
Diffuse porous-type		charcoal	-	3	1
Fendlera-type	fendlerbush	charcoal	FLS	1	1
Monocotyledon-type		fibrovascular bundles	OU	-	>9
Monocotyledon-type		leaf fragment	OU	-	>14
Monocotyledon-type (rugulose)		tissue	OU	-	3

continued...

Table E.14 Midden comparison 4: recovered archaeological remains, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol.1[b] CV14	Vol. 2[c] FV14
		Charred botanical and nonbotanical remains			
Wild plants continued.					
Opuntia (prickly pear)-type	prickly pear cactus	embryo	FN/OE?[f]	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed	FN/OE?[f]	-	1
Physalis longifolia-type	common groundcherry	seed	FW/OE	-	14
Poaceae-type (unknown)	grass family	stem fragment	OU	-	>8
Poaceae-type (type A)	grass family	stem segment	OU	-	2
Poaceae-type (type B)	grass family	stem segment	OU	-	>14
Poaceae-type (type C)	grass family	stem segment	OU	-	>25
Polygonum-type	bindweed	achene	FN/OE?[g]	-	1
Portulaca retusa-type	purslane	seed	FW/OE	-	6
Purshia tridentata-type	bitterbrush	leaf	OU	-	7
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	4	1
Ring porous-type		twig with buds	-	-	1
Stipa/Oryzopsis hymenoides-type	Indian ricegrass	floret	FW/OE	-	1
Yuccca baccata-type	datil yucca	leaf fragment	OU	-	16
Yucca/y. baccata-type	yucca/datil yucca	fiber clumps (worked)	OU/OW	-	5
Unknown botanical					
Achene (*Corispermum*-like)			-	-	2
Bud			-	-	5
Bud (type 1)			-	-	1
Bud (type 2)			-	-	1
Bud (type 3)			-	-	2
Bud (type 4)			-	-	2
Bud (type 5)			-	-	2
Leaf			-	-	2
Leaf (simple)			-	-	>6
Mealcake			-	-	2
Seed (elliptical)			-	-	1
Seed (plano-convex)			-	-	1
Seed (*Plantago*-like)			-	-	1
Seed (triangular)			-	-	1
Seedcoat (*Brassica*-like)			-	-	1
Tissue (papillose)			-	-	>6
Tissue (type 1)			-	-	1
Tissue (type 2)			-	-	1
Tissue (type 3)			-	-	1
Tissue (type 4)			-	-	1
Tissue (type 5)			-	-	1
Tissue (type 6)			-	-	1
Tissue (unknown)			-	-	>15
Tissue (vitrified)			-	-	>4
Type 2 Unknown			-	-	1
Nonbotanical					
Bone			-	-	3
Fecal pellet (insect unknown)			-	-	>3
Fecal pellet (termite)			OE	-	1
Carabidae	*Harpalus?*-type	elytra (forewings)	OE/OU	-	>25
Insect casing			-	-	7
Insect part			-	-	9

continued...

Table E.14 Midden comparison 4: recovered archaeological remains, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV14	Vol. 2[c] FV14
Uncharred botanical and nonbotanical remains					
Domesticates					
Cucurbita moschata-type	butternut squash	seed fragment	-	-	2
Cucurbita pepo-type	pumpkin	seed fragment	-	-	2
Cucurbita-type	gourd/squash	seedcoat	-	-	1
Zea mays	maize/corn	cupule	-	-	3
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	-	-	>10
Juniperus-type	juniper	bark fragment	-	-	>8
Pinus edulis-type	pinyon pine	bark fragment	-	-	3
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	embryo	-	-	1
Physalis longifolia-type	common groundcherry	seed	-	-	10
Purshia tridentata-type	cliffrose	leaf	-	-	2
Yucca baccata-type	datil yucca	fibers	-	-	1
Unknown botanical					
Bud			-	-	2
Leaf (simple)			-	-	>5
Leaf (unknown)			-	-	1
Seedcoat			-	-	1
Tissue (papillose)			-	-	>1
Nonbotanical					
Bone			-	-	2
Fecal pellet (insect unknown)			-	-	2
Ferrian illite/glauconite		mineral	OW	-	1
Hair/filament			-	-	1
Insect casing			-	-	1
Insect part			-	-	8

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 359, FS 203 (CCAC 2015a).

[c] Volume 2 results based on data from PD 359, FS 233 (this author).

[d] The presence of *Cucurbita* parts infers the use of the plant for food and other uses – gourds being used for vessels and spoons, etc.

[e] historic Pueblo use of *Lagenaria* rind is limited to the making of containers, although it is not unreasonable to presume the flesh would not have been wasted.

[f] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of harvest must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.

[g] The seasonality of *Polygonum* species achene production in the SCP area is uncertain.

Table E.15 Secondary refuse comparison 1: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	CV15a	Vol. 1[b] CV15b	Vol.2[c] FV15
Charred botanical and nonbotanical remains						
Domesticated plants						
Zea mays	maize, corn	cob fragment	FLZ	2	-	-
Zea mays	maize, corn	cupule	FLZ	12	20	-
Zea mays	maize, corn	kernel fragment	FD	18	6	1
Wild plants						
Gymnosperms						
Ephedra-type	ephedra	stem segment	FO/OU	-	-	2
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	-	1
Juniperus-type	juniper	charcoal	FLN	14	13	29
Pinus edulis-type	pinyon pine	cone scale	FLT	>8	-	-
Pinus edulis-type	pinyon pine	charcoal	FLN	-	-	6
Pinus-type	pine	bark scale	FLT	13	9	39
Pinus-type	pine	charcoal	FLN	3	2	-
Angiosperms						
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	1	2
Angiosperm-type (lenticular surface)		charcoal	-	-	-	>2
Artemisia tridentata-type	big sagebrush	charcoal	FLS	1	-	1
Cercocarpus-type	mountain mahogany	charcoal	FLS	1	-	-
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	5	-	-
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	1	-
Diffuse porous-type		charcoal	-	-	-	1
Fendlera-type	fendlerbush	charcoal	FLS	1	-	-
Monocotyledon-type		leaf	OU	-	-	3
Portulaca retusa-type	purslane	seed	FW/OE	1	-	-
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	-	-	1
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	3	-
Stipa/Oryzopsis hymenoides-type‡	Indian ricegrass	floret	FW/OE	52	-	-
Unknown botanical						
Bud (cluster)			-	1	-	-
Flowering head			-	-	-	1
Fruit			-	1	-	-
Seed (round, possibly segmented, 3 mm diameter)			-	1	-	-
Tissues (unspecified)			-	-	-	3
Nonbotanical						
Insect part			-	-	-	1
Uncharred botanical and nonbotanical remains						
Unknown botanical						
Disseminule			-	-	-	1
Nonbotanical						
Fecal pellet (insect unknown)			-	-	-	1
Insect casing			-	-	-	1
Insect cocoon			-	-	-	1
Insect parts (eggs)			-	-	-	1

Notes:

[a] “Occurrence” accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 839, FS 144 and PD 839, FS 148 (CCAC 2015a).

[c] Volume 2 results based on data from PD 839, FS 145 (this author).

‡ Identification noted to be “questionable.”

Table E.16 Secondary refuse comparison 2: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol.1[b] CV16	Vol. 2[c] FV16
Charred botanical and nonbotanical remains					
Domesticated plants					
Zea mays	maize, corn	cupule	FLZ	16	-
Wild plants					
Gymnosperms					
Ephedra-type	ephedra	stem fragment	FO/OU	>12	-
Gymnosperm unknown		charcoal	-	-	1
Juniperus-type (*J. osteosperma*-jvr)	juniper	twig, scale leaf	FLT	>50	-
Juniperus-type	juniper	charcoal	FLN	4	10
Pinus edulis-type	pinyon pine	charcoal	FLN	-	1
Pinus-type	pine	bark scale	FLT	1	6
Angiosperms					
Amaranthus-type	pigweed	seed	FW	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	5
Angiosperm-type (lenticular surface)		charcoal	-	-	>3
Cheno-am *(Chenopodium/Amaranthus)*	goosefoot/pigweed	seed, seedcoat	FW/OE	4	2
Opuntia (prickly pear)-type	prickly pear cactus	seed	FN/OE?[d]	14	-
Physalis longifolia-type	common groundcherry	seed	FW/OE	5	-
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	1	1
Semi-ring porous-type		charcoal	-	-	1
Stipa/Hesperostipa comata-type (cf)[e]	needle & thread grass	awn	OE/OU	-	1
Stipa/Oryzopsis hymenoides-type	Indian ricegrass	floret	FW/OE	2	-
Unknown botanical					
Bark fragment			-	-	1
Bud			-	1	-
Seed			-	6	-
Uncharred botanical and nonbotanical remains					
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	-	-	1
Pinus edulis-type	pinyon pine	needle fragment	-	-	1
Angiosperms					
Artemisia tridentata-type	big sagebrush	flowering head	-	-	1
Chenopodium-type	goosefoot	seedcoat	-	-	1
Descurainia-type	tansy mustard	seed	-	-	2
Mentzelia-type	stickleaf	seedcoat	-	-	3
Unknown botanical					
Disseminule			-	-	>9
Nonbotanical					
Bone			-	>30	1
Fecal pellet (insect unknown)			-	>3	>5
Fiber (modern)			-	-	>6
Insect casing			-	-	1
Insect part			-	-	3

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 1124, FS 184 (CCAC 2015a).

[c] Volume 2 results based on data from PD 1124, FS 186 (this author).

[d] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of harvest must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.

[e] Compares favourably.

Table E.17 Secondary refuse comparison 3: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV17	Vol. 2[c] FV17
Charred botanical and nonbotanical remains					
Domesticated plants					
Zea mays	maize, corn	cob fragment	FLZ	-	8
Zea mays	maize, corn	cupule	FLZ	50	18
Zea mays	maize, corn	glume	FLZ	-	2
Zea mays	maize, corn	kernel fragment	FD	-	4
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	1
Juniperus-type	juniper	charcoal	FLN	9	8
Pinus edulis-type	pinyon pine	charcoal	FLN	-	4
Pinus-type	pine	bark scale	FLT	1	7
Angiosperms					
Acer-type	maple	charcoal	FLS	1	-
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	2
Angiosperm-type		charcoal	-	-	1
Angiosperm-type (lenticular surface)		charcoal	-	-	4
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	6
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	FW/OE	7	-
Diffuse porous-type		charcoal	-	-	1
Physalis longifolia-type	common groundcherry	seed	FW/OE	1	-
Poaceae-type	grass family	caryopsis	FW	1	-
Poaceae (type A)	grass family	stem segment	OU	-	1
Populus/Salix-type	cottonwood/willow	charcoal	FLS	1	-
Unknown botanical					
Fruit rind			OU	8	-
Tissue (unknown)			-	-	3
Charcoal			-	1	>1
Nonbotanical					
Black spherical body			-	-	3
Uncharred botanical and nonbotanical remains					
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	1
Unknown botanical					
Disseminule			-	-	>12
Twig			-	-	>1
Nonbotanical					
Fecal pellet (insect unknown)			-	-	2
Insect part			-	-	5

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results are based on data from PD 1091, FS 18 (CCAC 2015a).

[c] Volume 2 results are based on data from PD 1091, FS 17 (this author).

Table E.18 Secondary refuse comparison 4: recovered archaeological remains.

Taxon/Occurrence[a]	Common name	Part	Interpretative category	Vol. 1[b] CV18	Vol. 2[c] FV18
		Charred botanical and nonbotanical remains			
Domesticated plants					
Zea mays	maize, corn	cob fragment	FLZ	-	1
Zea mays	maize, corn	cob segment	FLZ	-	1
Wild plants					
Gymnosperms					
Juniperus-type	juniper	charcoal	FLN	5	2
Pinus edulis-type	pinyon pine	charcoal	FLN	-	11
Pinus-type	pine	bark scale	FLT	-	8
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	1	4
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	10
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	2
Diffuse porous-type		twig	-	-	1
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	6	-
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	2
Quercus-type	oak	charcoal	FLS	1	1
Unknown botanical					
Leaf			-	-	1
Nutshell fragment			FO	-	1
Nonbotanical					
Fecal pellet (insect unknown)			-	-	>1
		Uncharred botanical and nonbotanical remains			
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	-	-	1
Angiosperms					
Artemisia tridentata-type	big sagebrush	leaf	-	-	1
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	-	2
Unknown botanical					
Disseminule			-	-	1
Twig			-	-	1
Nonbotanical					
Bone			-	1	-
Fecal pellet (insect unknown)			-	-	>7
Insect part			-	-	8

Notes:
[a] “Occurrence” accounts for materials that do not confidently meet criteria of family, genera or species.
[b] Volume 1 based on data from PD 1064, FS 18 (CCAC 2015a).
[c] Volume 2 based on data from analysis of PD 1055, FS 4 (this author).

Table E.19 Secondary refuse comparison 5: recovered archaeological remains.

Taxon/Occurrence[a]	**Common name**	**Part**	**Interpretative category**	**Vol. 1**[b] **CV19**	**Vol. 2**[c] **FV19**
			Charred botanical and nonbotanical remains		
Domesticated plants					
Cucurbita-type	gourd/squash	seed fragment	FD	1	-
Wild plants					
Gymnosperms					
Juniperus-type	juniper	charcoal	FLN	8	20
Pinus edulis-type	pinyon pine	charcoal	FLN	-	1
Pinus-type	pine	bark scale	FLT	-	5
Pinus-type	pine	charcoal	FLN	-	1
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	twig	FLT	-	7
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	3
Angiosperm-type		twig	-	-	1
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	3
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	1	-
Diffuse porous-type		charcoal	-	-	1
Monocotyledon-type		leaf	OU	-	1
Poaceae-type	grass family	stem fragment	OU	-	4
Populus/Salix-type	cottonwood/willow	charcoal	FLS	-	1
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	-	3
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	2	-
Semi-ring porous-type		charcoal	-	-	1
Stipa/Hesperostipa comata-type (cf)[d]	needle & thread grass	awn	OE/OU	-	1
Unknown botanical					
Fiber (modified)			OW	-	1
Tissue (papillose)			-	-	1
Tissue (unknown)			-	-	3
Nonbotanical					
Insect part			-	-	>6
			Uncharred botanical and nonbotanical remains		
Unknown botanical					
Disseminule			-	-	>11
Twig			-	-	>3
Nonbotanical					
Black spherical body			-	-	2
Fecal pellet (insect unknown)			-	2	>2
Insect casing			-	-	>2
Insect part			-	-	>1

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 results based on data from PD 1259, FS 40 (CCAC 2015a).

[c] Volume 2 based on data from analysis of PD 1259, FS 35 (this author).

[d] Compares favourably.

Table E.20 Secondary refuse comparison 6: recovered archaeological remains.

Taxon/Occurrence[a]	**Common name**	**Part**	**Interpretative category**	**Vol. 1**[b] **CV20**	**Vol. 2**[c] **FV20**
		Charred botanical and nonbotanical remains			
Domesticated plants					
Cucurbita moschata-type	butternut squash	seed	FD	-	18
Cucurbita-type	gourd/squash	rind	FD	-	1
Cucurbita-type	gourd/squash	seed	FD	-	21
Lagenaria-type	gourd	rind	OU	-	1
Zea mays	maize, corn	cob fragment	FLZ	-	1
Wild plants					
Gymnosperms					
Ephedra-type	ephedra	stem with developing cones	FO/OE/OU	-	19
Ephedra-type	ephedra	charcoal	FLS	-	17
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	6
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	10
Juniperus-type	juniper	bark fragment	FLT	-	1
Juniperus-type	juniper	charcoal	FLN	1	4
Pinus edulis-type	pinyon pine	charcoal	FLN	-	5
Pinus ponderosa-type	ponderosa pine	needle fragment	FLT	-	6
Angiosperms					
Amelanchier utahensis-type	Utah serviceberry	bud	OU/OE	-	6
Amelanchier utahensis-type	Utah serviceberry	twig	FLT	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	2
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	4
Cercocarpus-type	mountain mahogany	twig	FLT	-	3
Cercocarpus –type	mountain mahogany	charcoal	FLS	-	5
Dicotyledon-type		leaf	-	-	4
Monocotyledon-type		leaf (with fvb)[e]	OU	-	3
Monocotyledon-type		stem fragment	OU	-	1
Poaceae (type A)	grass family	stem fragment	OU	-	2
Portulaca retusa-type	purslane	seed	FW/OE	-	1
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	10	1
Rosaceae-type	rose family	charcoal	-	-	4
Semi-ring porous-type		charcoal	-	-	1
Yucca baccata-type	datil yucca	leaf fragment	OU	-	27
Yucca baccata-type	datil yucca	stalk segment	OU	-	2
Yucca/y.baccata-type	yucca/datil yucca	fibers (modified)	OW	-	>3
Unknown botanical					
Bud			-	-	8
Developing cone			-	-	1
Fiber (modified)			-	-	3
Flowering head			-	-	4
Fruit rind			-	-	1
Seed			-	-	1
Seedcoat			-	-	1
Tissue (epidermis)			-	-	1
Tissue (papillose)			-	-	>7
Tissue (unknown)			-	-	2
Black spherical body			-	-	1
Unknown nonbotanical					
Bone			-	-	1
Fecal pellet (insect unknown)			-	-	>8
Fecal pellet (termite)			OE	-	5
Insect part			-	-	4

continued...

Table E.20 Secondary refuse comparison 6: recovered archaeological remains, continued.

Taxon/Occurrence[a]	**Common name**	**Part**	**Interpretative category**	**Vol. 1**[b] **CV20**	**Vol. 2**[c] **FV20**
		Uncharred botanical and nonbotanical remains			
Domesticated plants					
Cucurbita moschata-type	butternut squash	seed	-	-	9
Cucurbita-type	gourd/squash	parenchyma	-	-	1
Cucurbita-type	gourd/squash	seed	-	-	23
Lagenaria-type	gourd	rind	-	-	2
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	-	-	5
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	>1	2
Physalis longifolia-type	common groundcherry	seed	-	-	5
Portulaca retusa-type	purslane	seed	-	-	1
Unknown botanical					
Bark fragment			-	-	1
Disseminule			-	-	>1
Seed			-	-	1
Seed (ovoid)			-	-	2
Seed mash			-	-	>1
Seedcoat			-	-	1
Tissue (epidermis)			-	-	1
Tissue (unknown)			-	-	1
Nonbotanical					
Adobe fragments			-	-	>8
Fecal pellet (insect unknown)			-	-	1
Insect (beetle)			-	-	2
Insect casing			-	-	1
Insect part			-	-	>23

Notes:

[a] "Occurrence" accounts for materials that do not confidently meet criteria of family, genera or species.

[b] Volume 1 based on data from PD 1208, FS 16 (CCAC 2015a).

[c] Volume 2 based on data from PD 1208, FS 7 (this author).

[d] *Opuntia* (prickly pear) produces seeds in the fall that can remain on the plant until the following year. Assessments of seasonality of use must consider the long-term persistence seed pattern for this species vs. deliberate storage by people.

[e] fvb: fibrovascular bundles (monocotyledon).

Appendix F: Bulk volume comparison data by feature type

Table F.1 Burned spot summary: original and new findings (new sample data shaded).

Taxon/Occurrence[a]	Common name	Part	Interpretative Category	Burned spots 1[b] CV1a	CV1b	CV1c	FV1	Burned spots 2[c] CV2	FV2
Charred botanical and nonbotanical remains									
Domesticated plants									
Zea mays	maize, corn	cupule	FLZ	-	-	1	-	-	-
Zea mays	maize, corn	kernel	FD	-	-	-	-	1	-
Zea mays	maize, corn	kernel embryo	FD	-	-	-	-	1	-
Zea mays	maize, corn	kernel fragment	FD	-	-	-	1	-	-
Wild plants									
Gymnosperms									
Gymnosperm-type	unknown	charcoal	-	-	-	-	2	-	-
Juniperus-type	juniper	charcoal	FLN	12	7	17	16	-	13
Pinus edulis	pinyon pine	cone, umbo	FLT	-	-	-	-	-	2
Pinus edulis	pinyon pine	charcoal	FLN	-	-	-	2	-	2
Pinus-type	pine	bark scale	FLT	1	6	1	7	-	14
Pinus-type	pine	charcoal	FLN	1	5	1	-	-	-
Angiosperms									
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	pome	FO/OE	1	-	-	-	-	-
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	twig	FLT	-	-	-	-	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	-	2	1	-	4
Angiosperm-type	unknown	charcoal	-	-	-	-	-	-	1
Artemisia tridentata-type	big sagebrush	twig	FLT	-	-	-	-	-	1
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	2	-	4	-	14
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	-	-	23	-	1
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	-	-	2	1	4	-
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	-	-	-	-	3
Diffuse porous-type		charcoal	FLS	-	-	-	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed fragment	FN/OE	-	-	-	>1	-	-
Physalis longifolia-type	common groundcherry	seed	FW/OE	-	-	-	-	3	1
Portulaca retusa-type	purslane	seed	FW/OE	-	-	-	-	1	-
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	6	-	-	-	-

continued...

Table F.1 Burned spot summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretative Category	Burned spots 1[b] CV1a	CV1b	CV1c	FV1	Burned spots 2[c] CV2	FV2
Charred botanical and nonbotanical remains									
Wild plants continued									
Quercus-type	oak	charcoal	FLS	-	-	-	-	-	1
Salix-type (cf)[d]	willow (or cottonwood)	charcoal	FLS	-	-	-	-	-	1
Oryzopsis hymenoides-type	Indian ricegrass	floret/caryopsis	FW/OE	-	-	-	-	-	21
Unknown Botanical									
Black spherical body			-	-	-	-	1	-	-
Bud			-	-	-	-	-	1	-
Disseminule			-	-	-	-	1	-	-
Seed fragment			-	-	-	-	-	-	1
Twig			-	-	-	-	>1	-	-
Nonbotanical									
Fecal pellet (insect)			-	-	-	-	1	-	-
Fecal pellet (termite)			OE	-	-	1	-	-	-
Hair/filament			-	-	-	-	-	-	1
Uncharred botanical and nonbotanical remains									
Wild plants									
Gymnosperms									
Pinus edulis-type	pinyon pine	needle	-	-	-	-	-	-	1
Angiosperms									
Poaceae-type	grass	floret	-	-	-	-	-	-	>1
Sphaeralcea-type	globemallow	seed	-	-	-	-	-	-	1
Unknown botanical									
Disseminule			-	-	-	-	>10	-	>6
Twig			-	-	-	-	>1	-	-
Nonbotanical									
Fecal pellet (insect)			-	-	-	-	-	-	>3
Fiber (blue) modern			-	-	-	-	-	-	>1
Insect casing			-	-	-	-	-	-	2
Insect part			-	-	-	-	3	-	4

Notes:

[a] "Occurrence" accounts for unidentified/unidentifiable materials that do not fit a genera/species level of description.

[b] Burned spot 1 is represented by four samples: CV1a (PD 729, FS 1); CV1b (PD 732, FS 1); CV1c (PD 737, FS 1); and FV1 (PD 728, FS 1). All are individual burned spots.

[c] Burned spot 2 is represented by two samples: CV2 (PD 856, FS 1); and FV2 (PD 816, FS 2). Both are individual burned spots located inside rooms in architectural block 1000.

[d] Compares favorably.

Table F.2 Firepit summary: original and new findings.

Taxon/Occurrence[a]	Common name	Part	Interpretive Category	Firepit 1[b] CV3	Firepit 1[b] FV3	Firepit 2[c] CV4	Firepit 2[c] FV4	Firepits 3[d] CV5	Firepits 3[d] FV5
Charred botanical and nonbotanical remains									
Domesticated plants									
Zea mays	maize, corn	cob fragment	FLZ	-	-	-	-	4	-
Zea mays	maize, corn	cupule	FLZ	5	1	-	1	20	-
Zea mays	maize, corn	kernel	FD	-	-	-	4	1	6
Zea mays	maize, corn	kernel embryo	FD	-	-	-	-	-	1
Zea mays	maize corn	kernel fragment	FD	-	-	-	-	2	-
Wild plants									
Gymnosperms									
Gymnosperm-type	unknown	charcoal	-	-	1	-	-	-	-
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	-	5	5	-	1
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	-	-	3	-	-
Juniperus-type	juniper	cone	FLT	-	-	-	1	-	1
Juniperus-type	juniper	charcoal	FLN	7	18	10	13	10	16
Pinus edulis-type	pinyon pine	needle fragment	FLT	-	-	-	1	-	-
Pinus edulis-type	pinyon pine	charcoal	FLN	-	-	-	2	-	-
Pinus-type	pine	bark scale	FLT	-	14	24	>20	1	2
Pinus-type	pine	charcoal	FLN	3	4	-	-	-	-
Angiosperms									
Amaranthus-type	pigweed	seed	FW/OE	-	-	-	-	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	-	-	1	-	1
Angiosperm-type	unknown, lenticular surface	charcoal	-	-	-	-	-	-	>4
Artemisia/A. tridentata-type	big sagebrush	achene	FO/OE	-	-	-	-	-	2
Artemisia tridentata-type	big sagebrush	flowering head	OU/OE	-	-	-	-	-	8
Artemisia tridentata-type	big sagebrush	leaf	OU	-	-	-	-	-	4
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	-	-	3	-	4
Atriplex-type	saltbush	charcoal	FLS	-	-	-	3	-	-
Cercocarpus-type	mountain mahogany	charcoal	FLS	-	-	-	2	-	1
Cheno-am (*Chenopodium/Amaranthus)*	goosefoot/pigweed	seed	FW/OE	1	-	-	-	4	1
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	-	-	-	-	3
Fraxinus-type‡	ash	charcoal	FLS	-	-	1	-	-	-
Monocotyledon-type	type unknown	leaf	OU	-	-	-	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed (and fragments)	FN/OE?	-	-	-	-	4	(>28)
Physalis longifolia-type	common groundcherry	seed	FW/OE	4	-	1	-	2	-
Physalis longifolia-type	common groundcherry	seed coat	FW/OE	-	-	-	-	-	1

continued...

Table F.2 Firepit summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Firepit 1[b] CV3	FV3	Firepit 2[c] CV4	FV4	Firepits 3[d] CV5	FV5
Charred botanical and nonbotanical remains									
Poaceae, festucoid-type	grass family, festucoid	caryopsis	FW	-	-	-	1	-	-
Poaceae (type B)	grass family, unknown	stem segment	OU	-	-	-	1	-	-
Polanisia-type	clammyweed	seedcoat	FN/OE?	-	-	-	-	-	1
Polygonum-type	bindweed	achene	FN/OE?	-	-	-	-	-	1
Portulaca retusa-type	purslane	seed	FW/OE	-	1	-	-	-	-
Prunus/Rosa-type	chokecherry/rose	wood	FLS	-	-	1‡	-	10	-
Purshia tridentata-type	bitterbrush	leaf	OU	-	-	-	1	-	2
Yucca baccata-type	datil yucca	seed	FN/OE	-	-	-	-	1	-
Unknown botanical									
Disseminule			-	-	1	-	-	-	1
Flowering head			-	-	-	-	-	-	2
Leaf			-	-	-	-	1	-	2
Seed coat			-	-	-	-	-	-	1
Tissue (epidermis)			-	-	-	-	1	-	-
Tissue (type 7)			-	-	-	-	-	-	1
Tissue (type 8)			-	-	-	-	-	-	1
Tissue (unknown)			-	-	3	-	>12	-	>3
Tissue (vitrified)			-	-	3	-	-	-	-
Twig			-	-	-	-	-	1	-
Unknown			-	-	-	-	-	-	1
Nonbotanical				-	-	-	-	-	-
Black spherical body			-	-	1	-	-	-	-
Insect		fecal pellet	-	-	-	-	1	-	-
Uncharred botanical and nonbotanical remains									
Wild plants									
Gymnosperms									
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	3	-	2	-	-
Juniperus osteosperma-type	Utah juniper	twig	-	-	2	-	1	-	-
Pinus contorta-type	lodgepole pine	needle fragment	-	-	1	-	-	-	-
Pinus edulis-type	pinyon pine	needle fragment	-	-	1	-	-	-	-
Angiosperms (over)									

continued...

Table F.2 Firepit summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Firepit 1[b] CV3	Firepit 1[b] FV3	Firepit 2[c] CV4	Firepit 2[c] FV4	Firepits 3[d] CV5	Firepits 3[d] FV5
Uncharred botanical and nonbotanical remains									
Artemisia tridentata-type	big sagebrush	achene	-	-	-	-	-	-	1
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	-	4	-	-	-	-
Opuntia (prickly pear)-type	prickly pear	embryo	-	-	-	-	-	-	9
Opuntia (prickly pear)-type	prickly pear	seed	-	-	-	-	-	3	>16
Physalis longifolia-type	common groundcherry	seed		-	-	-	-	-	7
Poaceae-type	grass family	floret	-	-	2	-	-	-	-
Unknown botanical									
Disseminule			-	-	>10	-	>7	-	>9
Twig			-	-	>1	-	-	-	-
Nonbotanical									
Bone			-	-	-	-	-	-	1
Insect	termite	fecal pellet	OE	-	-	-	-	-	1
Insect		fecal pellet	-	-	>9	-	1	-	6
Insect		part	-	-	10	-	-	-	5

Notes:

[a] "Occurrence" accounts for unidentified/unidentifiable materials that do not fit a genera/species level of description.

[b] Firepit 1 is represented by two samples: CV3 (PD 849, FS 1) and FV3 (PD 849, FS 2). Both samples are from the same firepit.

[c] Firepit 2 is represented by two samples: CV4 (PD 847, FS 2) and FV4 (PD 847, FS 1). Both samples are from the same firepit.

[d] Firepit 3 is represented by two samples: CV5 (PD 874, FS 5) and FV5 (PD 875, FS 2). Each sample is from a different firepit located in a D-shaped tower room.

‡ Identification noted to be "questionable."

Table F.3 Hearth comparison summary: original and new findings.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Hearth 1[b] CV6	FV6	Hearth 2[c] CV7	FV7	Hearth 3[d] CV8	FV8	Hearth 4[e] CV9	FV9	Hearth 5[f] CV10	FV10
Charred botanical and nonbotanical remains													
Domesticated plants													
Cucurbita-type	gourd/squash	seed fragment	FD	-	-	1	-	-	-	-	-	-	-
Zea mays	maize, corn	cupule	FLZ	-	-	-	-	1	-	-	-	-	-
Wild plants													
Gymnosperms													
Gymnosperm-type	unknown	charcoal	-	-	-	-	-	-	1	-	-	-	-
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	-	-	1	-	-	-	18	-	-
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	-	-	2	-	-	-	5	-	-
Juniperus-type	juniper	charcoal	FLN	12	4	15	16	3	2	3	13	-	18
Pinus edulis-type	pinyon pine	charcoal	FLN	-	-	-	2	-	7	-	-	-	-
Pinus-type	Pine	bark scale	FLT	3	2	3	5	-	-	-	1	-	3
Pinus-type	Pine	charcoal	FLN	-	2	-	-	-	-	-	-	-	1
Angiosperms													
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	-	-	5	-	-	-	-	-	-	4
Amaranthus-type	pigweed	seed	FW/OE	-	-	-	-	-	-	-	1	-	-
Artemisia tridentata-type	big sagebrush	charcoal	FLS	-	-	-	3	-	-	-	-	-	1
Chenopodium-type	goosefoot	seed	FW/OE	-	-	-	-	-	-	-	1	-	-
Juncus-type	rush	achene	FN/OE/ OU	-	-	-	-	-	-	-	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed	FN/OE	-	-	-	-	2	-	-	-	-	-
Opuntia (prickly pear)-type	prickly pear cactus	seed fragment	FN/OE	-	-	2	-	-	-	-	-	-	-
Physalis longifolia-type	common groundcherry	seed	FW/OE	-	-	4	-	-	-	-	-	-	-
Semi-ring porous-type	hardwood unknown	charcoal	-	-	-	-	-	-	-	-	-	-	9
Oryzopsis hymenoides-type	Indian ricegrass	floret/ caryopsis	FW/OE	-	-	-	-	-	-	-	1	-	-
Unknown botanical													
Bud			-	-	-	-	2	-	1	-	-	-	-
Rind fragment			OU	-	-	-	-	-	-	-	-	-	8
Seed			-	-	-	1	-	-	-	-	-	-	-
Seed coat, *Sisybrium/Thelyodiopsis*-type[?]	tumblemustard-type [?]		OU	-	-	-	1	-	-	-	-	-	-
Tissue (unknown)			-	-	-	-	1	-	-	-	-	-	4
Tissue (vitrified)			-	-	4	-	-	-	-	-	-	-	31
Twig			-	-	>3	-	-	-	-	-	-	-	-

continued...

Table F.3 Hearth comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Hearth 1[b] CV6	Hearth 1[b] FV6	Hearth 2[c] CV7	Hearth 2[c] FV7	Hearth 3[d] CV8	Hearth 3[d] FV8	Hearth 4[e] CV9	Hearth 4[e] FV9	Hearth 5[f] CV10	Hearth 5[f] FV10
Charred botanical and nonbotanical remains													
Nonbotanical													
Bone			-	-	1	-	-	-	-	-	-	-	-
Insect part			-	-	-	-	-	-	-	-	1	-	-
Uncharred botanical and nonbotanical remains													
Wild plants													
Gymnosperms													
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	-	-	1	-	1	-	-	-	-
Juniperus osteosperma-type	Utah juniper	twig	-	-	3	-	-	-	-	-	1	-	1
Juniperus-type	Juniper	cone scale	-	-	-	-	1	-	-	-	-	-	-
Pinus edulis-type	pinyon pine	needle fragment	-	-	-	-	-	-	1	-	-	-	-
Angiosperms													
Artemisia tridentata-type	big sagebrush	leaf	-	-	-	-	-	-	1	-	-	-	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	-	-	-	-	-	1	-	-	-	-
Poaceae-type	Grass	floret	-	-	-	-	-	-	2	-	-	-	-
Poaceae-type	Grass	stem segment	-	-	-	-	-	-	-	-	-	-	1
Unknown botanical													
Disseminule			-	-	>7	-	>5	-	>5	-	>5	-	>10
Twig			-	-	>9	-	>1	-	>2	-	1	-	>3
Nonbotanical													
Bone			-	-	-	1	-	1	1	-	-	-	-
Gastropod (*Pupoides* sp.)		casing	OE/OU	-	-	-	-	-	1	-	-	-	-
Insect		fecal pellet	-	-	1	-	>3	-	>3	-	>4	-	>11
Insect		part/casing	-	-	-	-	-	-	1	-	>3	-	>4

Notes:

[a] "Occurrence" accounts for unidentified/unidentifiable materials that do not fit a genera/species level of description

[b] Hearth 1 is represented by two samples: CV6 (PD 1454, FS 10) and FV6 (PD 1454, FS 9). Both samples are from the same central hearth, kiva 400.

[c] Hearth 2 is represented by two samples: CV7 (PD 1482, FS 4) and FV7 (PD 1481, FS 3). Both samples are from the same central hearth, kiva 517.

[d] Hearth 3 is represented by two samples: CV8 (PD 1531, FS 2) and FV8 (PD 1530, FS 2). Both samples are from the same central hearth, kiva 601.

[e] Hearth 4 is represented by two samples: CV9 (PD 1432, FS 13) and FV9 (PD 1432, FS 14). Both samples are from the same central hearth, kiva 1010.

[f] Hearth 5: is represented by two samples: CV10 (PD 244, FS 1) and FV10 (PD 243, FS 5). Both samples are from the same central hearth, kiva 1206.

[?] Tentative identification.

Table F.4 Midden comparison summary: original and new findings.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Midden 1[b] CV11	FV11	Midden 2[c] CV12	FV12	Midden 3[d] CV13	FV13	Midden 4[e] CV14	FV14
Charred botanical and nonbotanical remains											
Domesticated plants											
Cucurbita moschata-type	butternut squash	seed fragment	FD	-	-	-	-	-	-	-	6
Cucurbita pepo-type	pumpkin	seed fragment	FD	-	-	-	-	-	-	-	8
Cucurbita-type	gourd/squash	peduncle	FD/OU?	-	-	-	-	-	-	-	1
Cucurbita-type	gourd/squash	rind fragment	FD/OU?	-	-	-	-	2	-	-	32
Lagenaria-type	gourd	rind fragment	OU/OW	-	-	-	-	-	-	-	8
Phaseolus vulgaris-type	common bean	cotyledon	FD	-	-	-	-	-	1	-	2
Zea mays	maize, corn	cob fragment	FLZ	3	11	-	-	-	1	50	>23
Zea mays	maize, corn	cob segment	FLZ	-	2	-	-	-	-	-	6
Zea mays	maize, corn	cupule	FLZ	2	20	5	1	16	2	10	>32
Zea mays	maize, corn	glume	FD/FLZ	-	-	-	-	-	-	-	4
Zea mays	maize, corn	immature kernel	FD	-	-	-	-	-	-	-	2
Zea mays	maize, corn	kernel	FD	-	-	-	-	1	-	-	-
Zea mays	maize, corn	kernel embryo	FD	-	-	-	-	-	-	-	3
Zea mays	maize corn	kernel fragment	FD	1	2	-	-	-	-	3	>26
Wild plants											
Gymnosperms											
Ephedra-type	ephedra	cone (developing)	OE/OU	-	-	-	-	-	-	-	>1
Ephedra-type	ephedra	cone (female)	OE/OU	-	-	-	-	-	-	-	>1
Ephedra-type	ephedra	stem segment	FO/OU	-	-	-	-	-	-	-	>94
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	-	-	1	-	-	-	>6
Juniperus osteosperma-type	Utah juniper	seed (modified)	OW	-	-	-	-	-	-	-	1
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	-	-	-	-	-	2	>34
Juniperus-type	juniper	bark	FLT	-	-	-	-	-	-	-	>28
Juniperus-type	juniper	charcoal	FLN	23	16	14	15	11	20	7	19
Pinus edulis-type	pinyon pine	bark fragment	FLT	-	-	-	-	-	-	-	4
Pinus edulis-type	pinyon pine	needle fragment	FLT	-	1	-	-	-	-	-	46
Pinus edulis-type	pinyon pine	twig	FLT	-	-	-	-	-	-	-	5
Pinus edulis-type	pinyon pine	charcoal	FLN	-	8	-	4	-	8	-	10
Pinus-type	pine	bark fragment	FLT	-	-	-	-	-	-	-	1
Pinus-type	pine	bark scale	FLT	7	19	1	2	17	3	1	>23
Pinus-type	pine	charcoal	FLN	6	-	5	1	6	1	2	-
Angiosperms											
Amaranthus-type	pigweed	seed	FW/OE	-	-	-	-	-	-	-	14

continued...

Table F.4 Midden comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Midden 1[b]		Midden 2[c]		Midden 3[d]		Midden 4[e]	
				CV11	FV11	CV12	FV12	CV13	FV13	CV14	FV14
Charred botanical and nonbotanical remains											
Wild plants											
Amelanchier Utahensis-type	Utah serviceberry	bud	OE/OU	-	-	-	-	-	-	-	>57
Amelanchier Utahensis-type	Utah serviceberry	twig	FLT	-	-	-	-	-	-	-	1
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	FLS	1	2	-	-	3	1	-	-
Angiosperm-type	unknown (lenticular surface)	charcoal	-	-	-	-	3	-	5	-	-
Angiosperm-type	unknown	charcoal	-	-	-	-	1	-	-	-	-
Artemisia/A.tridentata-type	big sagebrush	achene	FO/OE	-	-	-	-	-	-	-	7
Artemisia tridentata-type	big sagebrush	flowering head	OU/OE	-	-	-	-	-	-	-	32
Artemisia tridentata-type	big sagebrush	flower (immature)	OU/OE	-	-	-	-	-	-	-	5
Artemisia tridentata-type	big sagebrush	leaf	FLT/OU	-	-	-	-	-	-	-	8
Artemisia tridentata-type	big sagebrush	twig	FLT	-	-	-	-	-	-	-	>9
Artemisia tridentata-type	big sagebrush	charcoal	FLS	3	5	-	-	-	10	3	1
Atriplex-type	saltbush	bract fragment	OE/OU	-	-	-	-	-	-	-	1
Atriplex-type	saltbush	seed	FO/OE	-	-	-	-	-	-	-	1
Bromus-type (Panicoideae)	brome	caryopsis	FW	-	-	-	-	-	-	-	1
Ceratoides lanata-type	winterfat	twig	FLT	-	-	-	-	-	1	-	6
Cercocarpus-type	mountain mahogany	bud (and twig)	FLT	-	-	-	-	-	-	-	3
Cercocarpus-type	mountain mahogany	charcoal	FLS	1	-	-	-	1	1	-	1
Cheno-am (*Chenopodium/ Amaranthus)*	goosefoot/pigweed	seed	FW/OE	-	-	-	-	-	2	13	67
Chenopodium-type	goosefoot	seed	FW/OE	-	-	-	-	-	-	-	1
Chrysothamnus-type	rabbitbrush	charcoal	FLS	-	4	-	1	-	-	-	-
Diffuse porous-type	hardwood unknown	charcoal	-	4	-	-	-	-	-	3	1
Fendlera-type		charcoal	FLS	-	-	-	-	-	-	1	1
Monocotyledon-type		fibrovascular bundle	OU	-	-	-	-	-	-	-	>9
Monocotyledon-type	unknown	leaf fragment	OU	-	-	-	-	-	-	-	>14
Monocotyledon-type	unknown	tissue (rugulose)	OU	-	-	-	-	-	-	-	3
Opuntia (prickly pear)-type	prickly pear cactus	embryo	FN/OE	-	-	-	-	-	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed	FN/OE	-	-	-	-	-	-	-	1
Physalis longifolia-type	common groundcherry	seed	FW/OE	-	-	-	-	1	-	-	14
Poaceae (unknown)	grass family, unknown	stem fragment	OU	-	-	-	-	-	-	-	>8
Poaceae (type A)	grass family, unknown	stem segment	OU	-	-	-	-	-	-	-	2

continued…

Table F.4 Midden comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Midden 1[b]		Midden 2[c]		Midden 3[d]		Midden 4[e]	
				CV11	FV11	CV12	FV12	CV13	FV13	CV14	FV14
Charred botanical and nonbotanical remains											
Wild plants											
Poaceae (type B)	grass family, unknown	stem segment	OU	-	-	-	-	-	-	-	>14
Poaceae (type C)	grass family, unknown	stem segment	OU	-	-	-	-	-	-	-	>25
Polygonum-type	bindweed	achene	FN/OE?	-	-	-	-	-	-	-	1
Populus/Salix-type	cottonwood/willow	charcoal	FLS	1	-	-	-	-	-	-	-
Portulaca retusa-type	purslane	seed	FW/OE	-	-	-	-	-	-	-	6
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	-	-	1	2	-	-	-	-
Purshia mexicana-type	cliffrose	charcoal	FLS	-	-	-	1	-	-	-	-
Purshia tridentata-type	bitterbrush	leaf	OU	-	-	-	1	-	-	-	7
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	-	-	-	-	2	4	1
Quercus-type	oak	charcoal	FLS	1	-	-	-	-	-	-	-
Ring porous-type	hardwood unknown	twig with buds	-	-	-	-	-	-	-	-	1
Semi-ring porous-type	hardwood unknown	charcoal	-	-	1	-	-	-	-	-	-
Oryzopsis hymenoides-type	Indian ricegrass	floret	FW/OE	-	-	-	-	-	-	-	1
Yucca (*baccata*-type)	(datil) yucca	leaf fragment	OU	-	-	-	-	-	-	-	16
Yucca-type	yucca	fiber (worked)	OW	-	-	-	-	-	-	-	5
Unknown botanical											
Achene (*Corispermum*-like)			-	-	-	-	-	-	-	-	2
Bud			-	-	-	1	-	-	-	-	5
Bud (type 1)			-	-	-	-	-	-	-	-	1
Bud (type 2)			-	-	-	-	-	-	-	-	1
Bud (type 3)			-	-	-	-	-	-	-	-	2
Bud (type 4)			-	-	-	-	-	-	-	-	2
Bud (type 5)			-	-	-	-	-	-	-	-	2
Fruit		top	OU	-	1	-	-	-	-	-	-
Fruit		rind	OU	-	-	-	-	2	-	-	-
Leaf			-	-	-	-	-	-	-	-	2
Leaf (simple)			-	-	-	-	-	-	-	-	>6
Mealcake fragment			-	-	-	-	-	-	-	-	2
Seed (elliptical)			-	-	-	-	-	-	-	-	1
Seed (plano-convex)			-	-	-	-	-	-	-	-	1
Seed (*Plantago*-like)			-	-	-	-	-	-	-	-	1
Seed (triangular)			-	-	-	-	-	-	-	-	1
Seed coat (*Brassica*-like)			-	-	-	-	-	-	-	-	1

continued…

Table F.4 Midden comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Midden 1[b] CV11	Midden 1[b] FV11	Midden 2[c] CV12	Midden 2[c] FV12	Midden 3[d] CV13	Midden 3[d] FV13	Midden 4[e] CV14	Midden 4[e] FV14
Charred botanical and nonbotanical remains											
Wild plants											
Poaceae (type B)	grass family, unknown	stem segment	OU	-	-	-	-	-	-	-	>14
Poaceae (type C)	grass family, unknown	stem segment	OU	-	-	-	-	-	-	-	>25
Polygonum-type	bindweed	achene	FN/OE?	-	-	-	-	-	-	-	1
Populus/Salix-type	cottonwood/willow	charcoal	FLS	1	-	-	-	-	-	-	-
Portulaca retusa-type	purslane	seed	FW/OE	-	-	-	-	-	-	-	6
Prunus/Rosa-type	chokecherry/rose	charcoal	FLS	-	-	1	2	-	-	-	-
Purshia mexicana-type	cliffrose	charcoal	FLS	-	-	-	1	-	-	-	-
Purshia tridentata-type	bitterbrush	leaf	OU	-	-	-	1	-	-	-	7
Purshia-type	cliffrose/bitterbrush	charcoal	FLS	-	-	-	-	-	2	4	1
Quercus-type	oak	charcoal	FLS	1	-	-	-	-	-	-	-
Ring porous-type	hardwood unknown	twig with buds	-	-	-	-	-	-	-	-	1
Semi-ring porous-type	hardwood unknown	charcoal	-	-	1	-	-	-	-	-	-
Oryzopsis hymenoides-type	Indian ricegrass	floret	FW/OE	-	-	-	-	-	-	-	1
Yucca (*baccata*-type)	(datil) yucca	leaf fragment	OU	-	-	-	-	-	-	-	16
Yucca-type	yucca	fiber (worked)	OW	-	-	-	-	-	-	-	5
Unknown botanical											
Achene (*Corispermum*-like)			-	-	-	-	-	-	-	-	2
Bud			-	-	-	1	-	-	-	-	5
Bud (type 1)			-	-	-	-	-	-	-	-	1
Bud (type 2)			-	-	-	-	-	-	-	-	1
Bud (type 3)			-	-	-	-	-	-	-	-	2
Bud (type 4)			-	-	-	-	-	-	-	-	2
Bud (type 5)			-	-	-	-	-	-	-	-	2
Fruit		top	OU	-	1	-	-	-	-	-	-
Fruit		rind	OU	-	-	-	-	2	-	-	-
Leaf			-	-	-	-	-	-	-	-	2
Leaf (simple)			-	-	-	-	-	-	-	-	>6
Mealcake fragment			-	-	-	-	-	-	-	-	2
Seed (elliptical)			-	-	-	-	-	-	-	-	1
Seed (plano-convex)			-	-	-	-	-	-	-	-	1
Seed (*Plantago*-like)			-	-	-	-	-	-	-	-	1
Seed (triangular)			-	-	-	-	-	-	-	-	1
Seed coat (*Brassica*-like)			-	-	-	-	-	-	-	-	1

continued...

Table F.4 Midden comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Midden 1[b] CV11	FV11	Midden 2[c] CV12	FV12	Midden 3[d] CV13	FV13	Midden 4[e] CV14	FV14
Charred botanical and nonbotanical remains											
Tissue (papillose)			-	-	-	-	-	-	-	-	>6
Tissue (parenchyma)			-	-	-	-	-	-	1	-	-
Tissue (type 1)			-	-	-	-	-	-	-	-	1
Tissue (type 2)			-	-	-	-	-	-	-	-	1
Tissue (type 3)			-	-	-	-	-	-	-	-	1
Tissue (type 4)			-	-	-	-	-	-	-	-	1
Tissue (type 5)			-	-	-	-	-	-	-	-	1
Tissue (type 6)			-	-	-	-	-	-	-	-	1
Tissue (unknown)			-	-	>1	-	-	-	-	-	>15
Tissue (vitrified)			-	-	-	-	-	-	-	-	>4
Type 2 Unknown			-	-	-	-	-	-	-	-	1
Nonbotanical											
Black spherical body			-	-	5	-	-	-	>9	-	-
Bone			-	-	-	-	-	-	-	-	3
Carabidae (uncharred[?])	*Harpalus*-type[?][f]	elytra (forewings)	OE/OU	-	-	-	-	-	-	-	>25
Insect	termite	fecal pellet	OE/OU	-	-	-	-	-	1	-	1
Insect		fecal pellet	-	-	>2	-	1	3	2	-	>3
Insect casing, parts			-	-	-	-	-	-	-	-	16
Uncharred botanical and nonbotanical remains											
Domesticates											
Cucurbita moschata-type	butternut squash	seed fragment	-	-	-	-	-	-	-	-	2
Cucurbita pepo-type	pumpkin	seed fragment	-	-	-	-	-	-	-	-	2
Cucurbita-type	gourd/squash	seedcoat	-	-	-	-	-	-	-	-	1
Zea mays	maize/corn	cupule	-	-	-	-	-	-	-	-	3
Wild plants											
Gymnosperms											
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	>11	-	1	-	2	-	-
Juniperus osteosperma-type	Utah juniper	twig	-	-	>52	-	7	-	4	-	>10
Juniperus-type	juniper	bark fragment	-	-	-	-	-	-	-	-	>8
Juniperus-type	juniper	cone (male)	-	-	9	-	-	-	-	-	-
Pinus edulis-type	pinyon pine	bark fragment	-	-	-	-	-	-	-	-	3
Pinus edulis-type	pinyon pine	needle fragment	-	-	22	-	-	-	3	-	-
Angiosperms											
Artemisia tridentata-type	big sagebrush	leaf	-	-	-	-	-	-	1	-	-

continued...

Table F.4 Midden comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	Midden 1[b] CV11	Midden 1[b] FV11	Midden 2[c] CV12	Midden 2[c] FV12	Midden 3[d] CV13	Midden 3[d] FV13	Midden 4[e] CV14	Midden 4[e] FV14
Uncharred botanical and nonbotanical remains, wild plants											
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	-	-	-	1	-	-	-	1
Opuntia (prickly pear)-type	prickly pear	embryo	-	-	-	-	-	-	-	-	1
Physalis longifolia-type	common groundcherry	seed	-	-	-	-	-	-	-	-	10
Poaceae-type	grass family	floret	-	-	8	-	-	-	-	-	-
Portulaca retusa-type	purslane	seed	-	-	1	-	-	-	-	-	-
Purshia tridentata-type	cliffrose	leaf	-	-	-	-	-	-	-	-	2
Yucca or Y. baccata-type	datil yucca	fibers	-	-	-	-	-	-	-	-	1
Yucca baccata-type	datil yucca	capsule/pod	-	-	-	-	1	-	-	-	-
Unknown Botanical											
Bud			-	-	3	-	-	-	-	-	2
Disseminule			-	-	>8	-	>7	-	>7	-	-
Flowering head			-	-	>1	-	-	-	-	-	-
Leaf (simple)			-	-	-	-	-	-	-	-	>5
Leaf (unknown)			-	-	-	-	-	-	-	-	1
Seed coat			-	-	-	-	-	-	-	-	1
Tissue (papillose)			-	-	-	-	-	-	-	-	>1
Tissue (unknown)			-	-	-	-	>1	-	-	-	-
Nonbotanical											
Bone			-	-	2	-	-	1	-	-	2
Insect		fecal pellet	-	-	>5	-	>4	-	>7	-	2
Gastropod (Pupillidedae)	*Vertigo*-type	casing	OE/OU[?]	-	1	-	-	-	-	-	-
Hair/filament			-	-	-	-	-	-	-	-	1
Insect		casing	-	-	-	-	>1	-	-	-	1
Insect		part	-	-	13	-	>15	-	>5	-	8
Mineral	Ferrian illite/glauconite	fragment/worked	OW	-	-	-	-	-	-	-	1

Notes:

[a] "Occurrence" accounts for unidentified/unidentifiable materials that do not fit a genera/species level of description.

[b] Midden 1 is represented by three samples: CV11a (PD 184, FS 73), CV11b (PD 184, FS 76) and FV11 (PD 184, FS 126). All samples came from midden 209.

[c] Midden 2 is represented by two samples: CV12 (PD 701, FS 41) and FV12 (PD 701, FS 40). Both samples came from midden 515.

[d] Midden 3 is represented by three samples: CV13a (PD 1008, FS 107), CV13b (PD 1008, FS 113) and FV13 (PD 1008, FS 112). All from midden 803, associated with great kiva.

[e] Midden 4 is represented by two samples: CV14 (PD 359, FS 203) and FV14 (PD 359, FS 233). Both samples came from midden 1214, the "smouldering trash dump."

[f] Tentative identification.

[?] Questionable assessment.

Table F.5 Secondary refuse (SR) comparison summary: original and new findings.

Taxon/occurrence[a]	Common name	Part	Interpretive category	SR 1[b]		SR 2[c]		SR 3[d]		SR 4[e]		SR 5[f]		SR6[g]	
				CV15	**FV15**	**CV16**	**FV16**	**CV17**	**FV17**	**CV18**	**FV18**	**CV19**	**FV19**	**CV20**	**FV20**
Uncharred botanical and nonbotanical remains															
Domesticated plants															
Cucurbita moschata-type	butternut squash	seed	FD	-	-	-	-	-	-	-	-	-	-	-	18
Cucurbita-type	gourd/squash	rind†	-	-	-	-	-	-	-	-	-	-	-	-	1
Cucurbita-type	gourd/squash	seed	FD	-	-	-	-	-	-	-	-	1Δ	-	-	21
Lagenaria-type	gourd	rind†	OU	-	-	-	-	-	-	-	-	-	-	-	1
Zea mays	maize, corn	cob†	FLZ	2	-	-	-	-	8	-	1	-	-	-	1
Zea mays	maize, corn	cob*	FLZ	-	-	-	-	-	-	-	1	-	-	-	-
Zea mays	maize, corn	cupule	FLZ	32	-	16	-	50	18	-	-	-	-	-	-
Zea mays	maize, corn	glume	FD	-	-	-	-	-	2	-	-	-	-	-	-
Zea mays	maize corn	kernel†	FD	24	1	-	-	-	4	-	-	-	-	-	-
Wild plants															
Gymnosperms															
Ephedra-type	ephedra	cone	OE	-	-	-	-	-	-	-	-	-	-	-	>1[h]
Ephedra-type	ephedra	stem†	FO/OU	-	2	>12	-	-	-	-	-	-	-	-	>19
Ephedra-type	ephedra	charcoal	FLS/OU	-	-	-	-	-	-	-	-	-	-	-	17
Gymnosperm-type	type unknown	charcoal	-	-	-	-	1	-	-	-	-	-	-	-	-
Juniperus osteosperma-type	Utah juniper	scale leaf	FLT	-	1	>50‡	-	-	-	-	-	-	-	-	6
Juniperus osteosperma-type	Utah juniper	twig	FLT	-	-	>50‡	-	-	1	-	-	-	-	-	10
Juniperus-type	juniper	bark	FLT	-	-	-	-	-	-	-	-	-	-	-	1
Juniperus-type	juniper	charcoal	FLN	27	29	4	10	9	8	5	2	8	20	1	4
Pinus edulis-type	pinyon pine	cone scale	FLT	8	-	-	-	-	-	-	-	-	-	-	-
Pinus edulis-type	pinyon pine	charcoal	FLN	-	6	-	1	-	4	-	11	-	1	-	5
Pinus ponderosa-type	Ponderosa pine	needle†	FLT	-	-	-	-	-	-	-	-	-	-	-	6
Pinus-type	pine	bark scale	FLT	22	39	1	6	1	7	-	8	-	5	-	-
Pinus-type	pine	charcoal	FLN	5	-	-	-	-	-	-	-	-	1	-	-
Angiosperms															
Acer-type	maple	charcoal	FLS	-	-	-	-	1	-	-	-	-	-	-	-

continued...

Table F.5 Secondary refuse (SR) comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	SR 1[b]		SR 2[c]		SR 3[d]		SR 4[e]		SR 5[f]		SR6[g]	
				CV15	**FV15**	**CV16**	**FV16**	**CV17**	**FV17**	**CV18**	**FV18**	**CV19**	**FV19**	**CV20**	**FV20**
Charred botanical and nonbotanical remains															
Wild plants															
Angiosperms															
Amaranthus-type	pigweed	seed	FW/OE	-	-	-	1	-	-	-	-	-	-	-	-
Amelanchier utahensis-type	Utah serviceberry	bud	OU/OE	-	-	-	-	-	-	-	-	-	-	-	6
Amelanchier utahensis-type	Utah serviceberry	twig	FLT	-	-	-	-	-	-	-	-	-	-	-	6
Amelanchier/ Peraphyllum-type	serviceberry/ peraphyllum	twig	FLT	-	-	-	-	-	-	-	-	-	7	-	-
Amelanchier/ Peraphyllum-type	serviceberry/ peraphyllum	charcoal	FLS	1	2	-	5	-	2	1	4	-	3	-	2
Angiosperm-type	unknown (lenticular surface)	charcoal	-	-	>2	-	>3	-	4	-	-	-	-	-	-
Angiosperm-type	unknown	twig/ charcoal	-	-	-	-	-	-	1	-	-	-	1	-	-
Artemisia tridentata-type	big sagebrush	charcoal	FLS	1	1	-	-	-	6	-	-	-	-	-	4
Cercocarpus-type	mountain mahogany	twig	FLT/FLS	1	-	-	-	-	-	-	-	-	-	-	3
Cercocarpus-type	mountain mahogany	charcoal	FLS	1	-	-	-	-	-	-	10	-	3	-	5
Cheno-am (*Chenopodium/ Amaranthus)*	goosefoot/ pigweed	seed	FW/OE	5	-	4	2	7	-	-	-	1	-	-	-
Chrysothamnus-type	rabbitbrush	charcoal	FLS	1	-	-	-	-	-	-	2	-	-	-	-
Dicotyledon-type	unknown	leaf	-	-	-	-	-	-	-	-	-	-	-	-	4
Diffuse porous-type	unknown	charcoal	-	-	-	-	-	-	-	-	-	-	1	-	-
Fendlera-type			FLS	1	-	-	-	-	-	-	-	-	-	-	-
Monocotyledon-type		leaf†	OU	-	3	-	-	-	-	-	-	-	1	-	3
Monocotyledon-type		stem*	OU	-	-	-	-	-	-	-	-	-	-	-	1
Opuntia (prickly pear)-type	prickly pear cactus	seed	FN/OE	-	-	14	-	-	-	-	-	-	-	-	-

continued...

Table F.5 Secondary refuse (SR) comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	SR 1[b] CV15	SR 1[b] FV15	SR 2[c] CV16	SR 2[c] FV16	SR 3[d] CV17	SR 3[d] FV17	SR 4[e] CV18	SR 4[e] FV18	SR 5[f] CV19	SR 5[f] FV19	SR6[g] CV20	SR6[g] FV20
Charred botanical and nonbotanical remains															
Wild plants															
Physalis longifolia-type	common groundcherry	seed	FW/OE	-	-	5	-	1	-	-	-	-	-	-	-
Poaceae (unknown)	grass family	caryopsis	FW	-	-	-	-	1	-	-	-	-	4	-	-
Poaceae (type A)	grass family	stem*	OU	-	-	-	-	-	1	-	-	-	-	-	2
Populus/Salix-type	cottonwood/ willow	charcoal	FLS	-	-	-	-	1	-	-	-	-	1	-	-
Portulaca retusa-type	purslane	seed	FW/OE	1	-	-	-	-	-	-	-	-	-	-	1
Prunus/Rosa-type	chokecherry/ rose	charcoal	FLS	-	1	1	1	-	-	6	-	-	3	10	1
Rosaceae-type	rose family	charcoal	-	-	-	-	-	-	-	-	-	-	-	-	4
Purshia-type	cliffrose/ bitterbrush	charcoal	FLS	3	-	-	-	-	-	-	2	2	-	-	-
Quercus-type	oak	charcoal	FLS	-	-	-	-	-	-	1	1	-	-	-	-
Semi-ring porous-type	hardwood	charcoal	-	-	-	-	1	-	-	-	-	-	1	-	1
Stipa/Hespirostipa comata-type (cf)	needle-and-thread grass	awn	OE/OU	-	-	-	1	-	-	-	-	-	1	-	-
Oryzopsis hymenoides-type	Indian ricegrass	floret	FW/OE	52‡	-	2	-	-	-	-	-	-	-	-	-
Yucca baccata-type	datil yucca	leaf†	OU	-	-	-	-	-	-	-	-	-	-	-	27
Yucca baccata-type	datil yucca	stem*	OU	-	-	-	-	-	-	-	-	-	-	-	2
Yucca-type	yucca	fiber twist	OU/OW	-	-	-	-	-	-	-	-	-	-	-	>3
Unknown botanical															
Bark			-	-	-	-	1	-	-	-	-	-	-	-	8
Bud			-	>1	-	1	-	-	-	-	-	-	-	-	-
Cone (developing)			-	-	-	-	-	-	-	-	-	-	-	-	1
Fiber (modified)			-	-	-	-	-	-	-	-	-	-	1	-	3
Flowering head			-	-	1	-	-	-	-	-	-	-	-	-	4
Fruit			-	1	-	-	-	-	-	-	-	-	-	-	-
Fruit		rind	OU	-	-	-	-	8	-	-	-	-	-	-	1
Leaf			-	-	-	-	-	-	-	-	1	-	-	-	-
Nutshell		fragment	FO?	-	-	-	-	-	-	-	1	-	-	-	-
Seed			-	1	-	6	-	-	-	-	-	-	-	-	1

continued...

Table F.5 Secondary refuse (SR) comparison summary: original and new findings, continued.

Taxon/Occurrence[a]	Common name	Part	Interpretive category	SR 1[b] CV15	SR 1[b] FV15	SR 2[c] CV16	SR 2[c] FV16	SR 3[d] CV17	SR 3[d] FV17	SR 4[e] CV18	SR 4[e] FV18	SR 5[f] CV19	SR 5[f] FV19	SR6[g] CV20	SR6[g] FV20
Charred botanical and nonbotanical remains															
Unknown botanical															
Unknown botanical															
Tissue (epidermis)			-	-	-	-	-	-	-	-	-	-	-	-	1
Tissue (papillose)			-	-	-	-	-	-	-	-	-	-	1	-	>7
Tissue (unknown)			-	-	3	-	-	-	3	-	-	-	3	-	2
Nonbotanical															
Black spherical body			-	-	-	-	-	-	3	-	-	-	-	-	1
Bone			-	-	-	-	-	-	-	-	-	-	-	-	1
Insect	termite	fecal pellet	OE	-	-	-	-	-	-	-	-	-	-	-	5
Insect		fecal pellet	-	-	-	-	-	-	-	-	>1	-	-	-	>8
Insect		part	-	-	1	-	-	-	-	-	-	-	>6	-	4
Uncharred botanical and nonbotanical remains															
Domesticated plants															
Cucurbita moschata-Type	butternut squash	seed	-	-	-	-	-	-	-	-	-	-	-	-	9
Cucurbita-type	squash/gourd	parenchyma	-	-	-	-	-	-	-	-	-	-	-	-	1
Cucurbita-type	squash/gourd	seed	-	-	-	-	-	-	-	-	-	-	-	-	23
Lagenaria-type	bottlegourd	rind†	-	-	-	-	-	-	-	-	-	-	-	-	2
Wild plants															
Gymnosperms															
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	-	-	-	-	1	-	-	-	-	-	-
Juniperus osteosperma-type	Utah juniper	twig	-	-	-	-	1	-	-	-	1	-	-	-	5
Pinus edulis-type	pinyon pine	needle†	-	-	-	-	1	-	-	-	-	-	-	-	-
Angiosperms															
Artemisia tridentata-type	big sagebrush	flowering head	-	-	-	-	1	-	-	-	-	-	-	-	-
Artemisia tridentata-type	big sagebrush	leaf	-	-	-	-	-	-	-	-	1	-	-	-	-
Chenopodium-type	goosefoot	seedcoat	-	-	-	-	1	-	-	-	-	-	-	-	-
Cheno-am	goosefoot/ pigweed	seed	-	-	-	-	-	-	-	-	2	-	-	>1	2

continued...

Table F.5 Secondary refuse (SR) comparison summary: original and new findings, continued.

	Common		Interpretive	SR 1[b]		SR 2[c]		SR 3[d]		SR 4[e]		SR 5[f]		SR6[g]	
Taxon/Occurrence[a]	**name**	**Part**	**category**	**CV15**	**FV15**	**CV16**	**FV16**	**CV17**	**FV17**	**CV18**	**FV18**	**CV19**	**FV19**	**CV20**	**FV20**
Uncharred botanical and nonbotanical remains															
Descurainia-type	tansy mustard	seed	-	-	-	-	2	-	-	-	-	-	-	-	-
Mentzelia-type	stickleaf	seedcoat	-	-	-	-	3	-	-	-	-	-	-	-	-
Physalis longifolia-type	common groundcherry	seed	-	-	-	-	-	-	-	-	-	-	-	-	5
Portulaca retusa-type	purslane	seed	-	-	-	-	-	-	-	-	-	-	-	-	1
Unknown botanical															
Bark fragment			-	-	-	-	-	-	-	-	-	-	-	-	1
Disseminule			-	-	1	-	>9	-	>12	-	1	-	>11	-	>1
Seed			-	-	-	-	-	-	-	-	-	-	-	-	1
Seed (ovoid)			-	-	-	-	-	-	-	-	-	-	-	-	2
Seed (mash)			-	-	-	-	-	-	-	-	-	-	-	-	>1
Seed coat			-	-	-	-	-	-	-	-	-	-	-	-	1
Tissue (epidermis)			-	-	-	-	-	-	-	-	-	-	-	-	>1
Twig			-	-	-	-	-	-	>1	-	1	-	>3	-	-
Nonbotanical															
Adobe		fragment	-	-	-	-	-	-	-	-	-	-	-	-	>8
Black spherical body			-	-	-	-	-	-	-	-	-	-	2	-	-
Bone			-	-	-	>30	1	-	-	1	-	-	-	-	-
Hair/filament			-	-	-	-	>6	-	-	-	-	-	-	-	-
Insect (large)	beetle-type	casing	-	-	-	-	-	-	-	-	-	-	-	-	2
Insect (small)		casing	-	-	1	-	1	-	-	-	-	-	>2	-	1
Insect (small)		fecal pellet	-	-	1	>3	>5	-	2	-	>7	2	>2	-	1
Insect		part	-	-	>2	-	3	-	5	-	8	-	>1	-	>23

Notes:

[a] "Occurrence" accounts for unidentified/unidentifiable materials that do not fit a genera/species level of description.

[b] SR 1 is represented by three samples: CV15 is combined data from CV15a (PD 839, FS 144) and CV15b (PD 839, FS 148); and FV15 (PD 839, FS 145).

[c] SR 2 is represented by two samples: CV16 (PD 1124, FS 184) and FV16 (PD 1124, FS 186). Both came from trash accumulation 1500 outside of the D-shaped building.

[d] SR 3 is represented by two samples: CV17 (PD 1091, FS 18) and FV17 (PD 1091, FS 17). Both samples came from trash deposited on the floor of the great kiva.

[e] SR 4 is represented by two samples: CV18 (PD 1064, FS 18) and FV18 (PD 1055, FS 4). Both samples came from a "storage" room (1507) in the D-shaped building.

[f] SR5 is represented by two samples: CV19 (PD 1259, FS 40) and FV19 (PD 1259, FS 35). Both samples came from refuse deposited in the D-shaped building (room1511).

[g] SR6 is represented by two samples: CV20 (PD 1208, FS 16) and FV20 (1208, FS 7). Both samples came from refuse deposited in the D-shaped building (room 1513).

[h] Multiple specimens of developing cones were observed on ephedra stems, number of cones uncounted.

† Fragment.

* Segment.

‡ Identification noted to be "questionable" in the original analysis.

Δ The original analysis identified >50 *Juniperus*-type twigs and scale leaves. *J. osteosperma*-type scale leaves are diagnostic of the species. I have placed them in this category for the purpose of comparison.

Appendix G: Species-area curve sample data

Table G.1 Archaeological remains, sample SC1 (PD 609, FS 3), courtyard 1000 firepit.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	1	1
Juniperus-type	juniper	charcoal	20	-	-
Pinus-type	pine	bark scale	-	1	-
Angiosperms					
Angiosperm-type		pith	-	2	>2
Angiosperm-type	(lenticular surface)	charcoal	-	>2	-
Angiosperm-type	unknown	charcoal	-	>3	>3
Artemisia tridentata-type	big sagebrush	achene	-	1	-
Artemisia tridentata-type	sagebrush	charcoal	-	2	3
Cercocarpus-type	mountain mahogany	charcoal	-	1	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	3	-	6
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed interior[d]	-	>2	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seedcoat	-	-	3
Physalis longifolia-type	common groundcherry	seed	1	-	-
Poaceae panicoid-type	panicoid grass	caryopsis	-	1	
Portulaca retusa-type	purslane	seed	-	-	5
Unknown botanical					
Black spherical body			-	-	11
Bud (6 types)			-	4	2
Seedcoat			-	1	-
Seed unknown (degraded)			-	2	-
Tissue (type 5)			-	>1	>18
Tissue (unknown-type)			-	>9	>20
Unknown			-	-	1
Wood charcoal			-	>1	9
Nonbotanical					
Insect casing			-	-	1
Uncharred botanical and nonbotanical remains					
Wild plants					
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	x†	2	4
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed interior[d]	-	-	7
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seedcoat	-	-	2
Unknown botanical					
Disseminule			-	>5	>29
Miscellaneous materials (modern)			x†	-	-
Twig			-	>2	-
Nonbotanical					
Black spherical body			-	-	7
Fecal pellet (insect unknown)			-	1	2
Fiber			-	-	2
Gastropod			-	3	1

continued…

Table G.1 Archaeological remains, sample SC1 (PD 609, FS 3), courtyard 1000 firepit, continued.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	.25 mm
Uncharred botanical and nonbotanical remains					
Nonbotanical continued.					
Insect casing			-	-	11
Insect part			-	-	5
Mineral unknown			-	-	1

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams et al. (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

[d] Seed interiors appear to be immature.

† Specimens recorded as present in incidental notes but not recorded in the CCAC database (2015a).

Table G.2 Archaeological remains, sample SC2 (PD 599, FS 3), room 1002 firepit.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Wild Plants					
Gymnosperms					
Juniperus-type	juniper	charcoal	4	-	-
Angiosperms					
Amaranthus-type	pigweed	seed	-	1	-
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	9	-	-
Angiosperm-type	lenticular surface	charcoal	-	>7	>25
Angiosperm-type	unknown	charcoal	-	-	>1
Artemisia tridentata-type	big sagebrush	charcoal	-	6	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	-	2
Monocotyledon-type		stem segment	-	1	2
Monocotyledon-type		tissue	-	-	1
Portulaca retusa-type	purslane	seed	-	-	1
"Sand Canyon" *Malva*-type	mallow	fruit schizocarp	-	1	4
Unknown botanical					
Black spherical body			-	-	9
Disseminule			-	-	3
Leaf fragment			-	1	1
Seed			-	-	2
Tissue (nodulose-type)			-	-	6
Tissue (type 5)			-	-	5
Tissue (unknown-type)			-	3	1
Nonbotanical					
Bone			-	1	-
Fecal pellet (insect unknown)			-	1	3
Insect casing			-	-	8
Insect part			-	1	4
Uncharred botanical and nonbotanical remains					
Wild Plants					
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed interior	-	1	-
Poaceae-type	grass family	floret	-	>2	-
Portulaca retusa-type	purslane	seedcoat	-	-	1
Unknown botanical					
Disseminule			-	>4	>24
Seedcoat			-	1	-
Nonbotanical					
Bone			-	-	8
Fecal pellet (insect unknown)			-	-	>15
Fibre			-	-	>20
Hair (?)			-	-	2
Insect casing			-	-	>66
Insect part			-	1	6

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] SAC data based on original analysis (Adams *et al.* 2007; CCAC 2015a).

[c] Results of additional analysis in 2009, this author by screen size (mm).

Table G.3 Archaeological remains, sample SC3 (PD 1543, FS 1), room 1527 firepit.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Domesticated Plants					
Zea mays	maize/corn	cob fragment	1	-	-
Zea mays	maize/corn	cupule	40	3	-
Zea mays	maize/corn	glume (fragment)	-	>6	-
Zea mays	maize/corn	glume (whole)	-	2	-
Zea mays	maize/corn	kernel (fragment)	51	3	-
Zea mays	maize/corn	kernel (whole)	1	1	-
Zea mays	maize/corn	kernel embryo	-	11	8
Wild Plants					
Gymnosperms					
Gymnosperm-type	unknown	charcoal	-	>9	>17
Juniperus-type	juniper	charcoal	14	-	-
Juniperus (*osteosperma*?)-type	juniper	twig	1	-	-
Pinus-type	pine	bark scale	-	2	-
Pinus-type	pine	charcoal	3	-	-
Angiosperms					
Angiosperm-type (lenticular surface)	unknown	charcoal	-	>13	>11
Artemisia tridentata-type	big sagebrush	flowering head	-	10	5
Artemisia tridentata-type	big sagebrush	charcoal	1	1	-
Bromus-type	brome grass (Pooideae)	caryopsis	-	1	-
Cercocarpus-type	mountain mahogany	charcoal	1	-	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	1
Opuntia (prickly pear)-type	prickly pear	seed	3	-	-
Physalis longifolia-type	common groundcherry	seed	2	6	-
Poaceae-type	grass family	caryopsis	-	-	1
Poaceae-type	grass family	floret	-	-	1
Portulaca retusa-type	purslane	seed	-	-	2
Purshia-type	cliff-rose/bitterbrush	charcoal	1	-	-
Quercus-type (cf)	oak	charcoal	-	1	-
Unknown botanical					
Bark fragment			-	1	-
Black spherical body			-	2	8
Bud (3 different types, .71 mm screen)			-	3	-
Bud (4 different types, .25 mm screen)			-	-	4
Leaf			-	1	-
Seed (>4.75 mm)			1	-	-
Seed fragment (>2.80mm)			1	-	-
Tissue (epidermis-type)			-	>8	>17
Tissue (parenchyma-type)			-	>13	>18
Tissue (rugulose-type)			-	2	-
Tissue (type 5)			-	>13	>17
Tissue (unknown-type)			-	>4	-
Tissue (vitrified-type)			-	>4	>9
Nonbotanical					
Adobe fragment			-	1	-

continued...

Table G.3 Archaeological remains, sample SC3 (PD 1543, FS 1), continued.

Taxon/occurrence[a]	**Common name**	**Part**	**SAC data**[b]	**New data**[c] **.71 mm**	**.25 mm**
		Charred botanical and nonbotanical remains continued			
Nonbotanical con't.					
Fecal pellet (insect unknown)			-	1	-
Insect casing			-	-	2
Insect part			-	-	>10
		Uncharred botanical and nonbotanical remains			
Wild Plants					
Angiosperm					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed (immature)	seed, interior	-	-	2
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seedcoat	-	-	1
Physalis longifolia-type	common groundcherry	seed	-	1	-
Portulaca retusa-type	purslane	seed	-	-	1
Unknown Botanical					
Black spherical body			-	3	>4
Disseminule			-	-	1
Tissue (epidermis)			-	-	1
Tissue (unknown-type, modern)			-	>6	>21
Twig			-	2	-
Nonbotanical					
Adobe fragment			-	1	-
Gastropod			-	-	1
Fecal pellet (>.71 mm)			-	-	1
Fecal pellet (insect unknown)			-	>7	>23
Fiber (modern)			-	2	1
Filament			-	1	-
Hair (?)			-	-	2
Insect casing			-	-	1
Insect part			-	13	>26

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Table G.4 Archaeological remains, sample SC4 (PD 147, FS 4), kiva 102 hearth.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Domesticated Plants					
Zea mays	maize/corn	cupule	1	-	-
Wild Plants					
Gymnosperms					
Gymnosperm-type		charcoal	-	1	-
Juniperus osteosperma-type	Utah juniper	scale leaf	-	1	1
Juniperus osteosperma-type	Utah juniper	twig	-	1	-
Juniperus-type	juniper	charcoal	18	-	-
Pinus-type	pine	bark scale	4	5	5
Angiosperms					
Angiosperm-type (lenticular surface)	unknown	charcoal	-	2	-
Artemisia tridentata-type (cf)	big sagebrush	charcoal	-	2	-
Cercocarpus-type	mountain mahogany	charcoal	1	-	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	1
Monocotyledon-type		fibrovascular bundle	-	1	3
Nicotiana-type	wild tobacco	seed	-	1	-
Physalis longifolia-type	common groundcherry	seed	-	1	-
Portulaca retusa-type	purslane	seed	-	1	1
Quercus-type	oak	charcoal	1	-	-
Unknown botanical					
Black spherical body			-	1	3
Bud (2 different types, .71 mm screen)			-	2	-
Bud (1 type, .25 mm screen)	overwintering type		-	-	1
Tissue (unknown-type)			-	3	-
Wood charcoal			-	>17	>33
Nonbotanical					
Bone			-	-	1
Insect part			-	-	2
Uncharred botanical and nonbotanical remains					
Unknown botanical					
Disseminule			-	>16	>33
Nonbotanical					
Fecal pellet (insect unknown)			-	15	>41
Insect casing			-	1	5
Insect part			-	-	1

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Table G.5 Archaeological remains, sample SC5 (PD 1582, FS 4), kiva 600 hearth.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Wild Plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	>3	1
Juniperus osteosperma-type	Utah juniper	twig	-	>1	-
Juniperus-type	juniper	charcoal	1	-	
Angiosperms					
Cercocarpus-type	mountain mahogany	charcoal	-	1	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	1
Unknown botanical					
Bud (.71 mm screen)			-	1	-
Disseminule			-	-	1
Tissue (unknown-type)			-	3	-
Tissue (vitrified-type)			-	2	-
Wood charcoal			-	>1	>2
Nonbotanical					
Bone			-	-	>4
Insect casing			-	1	1
Insect part			-	-	>2
Uncharred botanical and nonbotanical remains					
Unknown botanical					
Disseminule			-	>6	>9
Nonbotanical					
Fecal pellet (insect unknown)			-	1	-
Insect casing			-	-	1

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Table G.6 Archaeological remains, sample SC6 (PD 786, FS 8), midden 109.

Taxon/occurrence[a]	**Common name**	**Part**	**SAC data**[b]	**New data**[c] **.71 mm**	**.25 mm**
		Charred botanical and nonbotanical remains			
Domesticated plants					
Zea mays	maize/corn	cupule	8	-	-
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	1	5	1
Juniperus (*osteosperma*?)-type	juniper	twig	1	-	-
Juniperus-type	juniper	charcoal	14	-	-
Pinus-type	pine	bark scale	7	6	2
Pinus-type	pine	charcoal	4	-	-
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	1	1	1
Poaceae, festucoid-type	festucoid grass family	caryopsis	-	2	2
Prunus/Rosa-type	chokecherry/rose	charcoal	2	-	-
Unknown botanical					
Black spherical body			-	1	>5
Bud			-	1	-
Bud			-	1	-
Bud			-	-	1
Disseminule			-	1	-
Seed (unknown, fragment)			-	1	-
Tissue (epidermis-type)			-	1	-
Tissue (parenchyma-type)			-	1	-
Tissue (unknown-type)			-	1	-
Nonbotanical					
Insect part			-	-	2
		Uncharred botanical and nonbotanical remains			
Wild plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	twig	-	1	-
Angiosperms					
Poaceae, festucoid-type	festucoid grass family	caryopsis	-	>1	1
Unknown botanical					
Black spherical body			-	-	>2
Seed (immature, round)			-	2	-
Seed (immature, ovoid, *croton*-like)			-	1	-
Nonbotanical/other					
Fecal pellet (insect unknown)			-	>5	>7
Insect cocoon			-	1	-
Unknown			-	1	-
White spherical body			-	>1	4

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Table G.7 Archaeological remains, sample SC7 (PD 701, FS 41), kiva 517 hearth.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Domesticated Plants					
Zea mays	maize/corn	cupule	5	-	-
Wild Plants					
Gymnosperms					
Juniperus-type	juniper	charcoal	14	-	-
Pinus-type	pine	bark scale	1	>7	>3
Pinus-type	pine	charcoal	5	-	-
Angiosperms					
Chenopodium-type	goosefoot	seed	-	1	-
Portulaca retusa-type	purslane	seed	-	-	2
Prunus/Rosa-type	chokecherry/rose	charcoal	1	-	-
Unknown botanical					
Bud			1	-	-
Disseminule			-	-	2
Nonbotanical					
Black spherical body			-	-	>11
Fecal pellet (insect unknown)			-	-	>1
Fecal pellet (termite)			-	-	1
Insect cocoon			-	-	1
Uncharred botanical and nonbotanical remains					
Wild Plants					
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seedcoat	-	1	1
Chenopodium-type	goosefoot	seed	-	>6	-
Unknown botanical					
Disseminule			-	>2	>12
Nonbotanical					
Fecal pellet (insect unknown)			-	>10	>12
Insect casing			-	-	>7
Insect cocoon			-	1	1
Insect part			-	>1	2

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Table G.8 Archaeological remains, sample SC8 (PD 1008, FS 113), midden 803.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	.25 mm
Charred botanical and nonbotanical remains					
Domesticated Plants					
Zea mays	maize/corn	cupule	8	-	-
Zea mays	maize/corn	kernel	1	-	-
Wild Plants					
Gymnosperms					
Gymnosperm-type		charcoal	-	>1	>2
Juniperus osteosperma-type	Utah juniper	scale leaf	-	2	2
Juniperus-type	juniper	charcoal	7	>2	-
Pinus edulis-type	pinyon pine	needle fragment	-	>8	7
Pinus-type	pine	bark scale	10	6	1
Pinus-type	pine	charcoal	2	-	-
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	3	-	-
Angiosperm-type	lenticular surface	charcoal	-	>3	>3
Angiosperm-type		charcoal	-	-	>3
Cercocarpus-type	mountain mahogany	charcoal	1	-	-
Chrysothamnus-type (cf)	rabbitbrush	charcoal	-	2	1
Diffuse porous-type		charcoal	-	2	-
Monocotyledon-type		stem pith	-	1	1
Unknown botanical					
Black spherical body			-	1	>17
Bud			-	1	1
Disseminule			-	1	-
Fruit rind (tentative identification)			1	-	-
Seed fragment			-	-	1
Seed-like fragment			-	1	-
Tissue, epidermis-type			-	-	1
Tissue, nodulose-type			-	-	2
Tissue, unknown-type			-	-	5
Wood charcoal, wood pith			-	>6	>13
Nonbotanical					
Fecal pellet (>.71 mm)			3	-	-
Fecal pellet (insect unknown)	4 types		-	1	45
Fecal pellet (termite)			-	-	1
Insect part			-	6	>9
Uncharred botanical and nonbotanical remains					
Wild Plants					
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	-	1	-
Portulaca retusa-type	purslane	seed	-	1	-
Unknown botanical					
Black spherical body			-	-	1
Disseminule			-	>20	-

continued...

Table G.8 Archaeological remains, sample SC8 (PD 1008, FS 113), continued.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	.25 mm
Nonbotanical					
Bone			-	-	1
Fecal pellet	4 types		-	25	>100
Insect casing			-	1	-
Insect cocoon			-	2	-
Insect part			-	>42	>37

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Table G.9 Archaeological remains, sample SC9 (PD 357, FS 51), midden 1214.

Taxon/occurrence[a]	Common name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
Charred botanical and nonbotanical remains					
Domesticated Plants					
Zea mays	maize/corn	cupule	1	-	-
Zea mays	maize/corn	kernel	1	-	-
Wild Plants					
Gymnosperms					
Gymnosperm-type		charcoal	-	-	>1
Juniperus osteosperma-type	Utah juniper	scale leaf	-	>13	11
Juniperus osteosperma-type	Utah juniper	twig	2	-	2
Juniperus-type	juniper	charcoal	3	-	-
Pinus edulis-type	pinyon pine	needle fragment	-	3	11
Pinus-type	pine	bark scale	4	-	-
Pinus-type	pine	charcoal	7	-	-
Angiosperms					
Amelanchier/Peraphyllum-type	serviceberry/peraphyllum	charcoal	2	-	-
Amaranthus-type	pigweed	seed	-	2	3
Angiosperm-type (lenticular surface)		charcoal	-	>3	>25
Artemisia tridentata-type	big sagebrush	achene	-	1	-
Atriplex-type	saltbush	charcoal	1	-	-
Ceratoides lanata-type (cf)	winterfat	twig	-	-	1
Chenopodium-type	goosefoot	seed	-	1	-
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed	6	-	3
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed	seed interior (immature)	-	-	2
Cyperaceae-type (*Juncus/Eleocharis*)	rush or sedge	stem segment	-	-	12
Eleocharis-type	spikerush	achene	-	4	12
Eleocharis-type	spikerush	seed	-	1	18
Fendlera-type	fendlerbush	charcoal	2	-	-
Helianthus annuus-type	common sunflower	achene	1	-	-
Leguminosae-type	legume family	seed	1	-	-
Monocotyledon-type		leaf	-	-	7
Monocotyledon-type		fibrovascular bundle	-	-	8
Nicotiana-type	wild tobacco	seedcoat	-	1	-
Physalis longifolia-type	common groundcherry	seed	-	4	-
Physalis longifolia-type	common groundcherry	seedcoat	2	1	1
Poaceae, festucoid-type	festucoid grass	caryopsis	-	1	-
Poaceae-type (unknown)	grass family	stem	-	2	>36
Poaceae-type (type A)	grass family	stem	-	-	>7
Poaceae-type (type B)	grass family	stem	-	14	>5
Poaceae-type (type D)	grass family	stem	-	-	>12
Polanisia-type	clammy-weed	seedcoat	-	-	1
Portulaca retusa-type	purslane	seed	1	2	4
Portulaca retusa-type	purslane	seedcoat	-	1	1
Prunus/Rosa-type	chokecherry/rose	charcoal	4	-	-
Ring porous-type		charcoal	1	-	-
Vaccaria-type (cf, charred?)	soapwort	seedcoat	-	1	-

continued…

Table G.9 Archaeological remains, sample SC9 (PD 357, FS 51), continued.

Taxon/occurrence[a]	Common Name	Part	SAC data[b]	New data[c] .71 mm	New data[c] .25 mm
		Uncharred botanical and nonbotanical remains			
Unknown botanical					
Flowering head			-	-	1
Seed (*Alyssum*-like)	(madwort-like)		-	1	-
Seed			-	-	1
Seedcoat (*Physalis*-like)	(groundcherry-like)		-	-	1
Seedcoat (unknown-type)			-	-	1
Tissue (nodulose-type)			-	7	>9
Tissue (type 5)			-	>29	>105
Tissue (unknown-type)			-	6	>17
Tissue (vitrified)			-	-	1
Nonbotanical					
Black spherical body			-	10	38.5
Bone			-	-	3
Fecal pellet (insect unknown)			-	>5	10
Fecal pellet (termite)			-	-	5
Insect casing, part			-	1	>1
		Uncharred botanical and nonbotanical remains			
Wild Plants					
Angiosperms					
Cheno-am (*Chenopodium/Amaranthus*)	goosefoot/pigweed (immature)	seed interior (whole and fragmented)	-	>97	>263
Unknown botanical					
Disseminule			-	-	>5
Fibre (unknown-type)			-	-	>2
Tissues (unknown-type)			-	-	>9
Nonbotanical					
Bone				6	25
Fecal pellet (insect unknown)				1	4
Fiber (modern)				-	>68
Insect casing				2	>4
Insect part				4	>62
Mineral (Ferrian Illite/Glauconite)				>387	>15737
Mineral (Quartz)				>64	>64

Notes:

[a] "Occurrence" designates all those unidentified/unidentifiable materials that do not fit the "taxon" level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

> Mineral (Quartz) quantities likely match those of Mineral (Ferrian Illite/Glauconite) but were not individually counted.

Table G.10 Archaeological remains, sample SC10 (PD 715, FS 5), courtyard 513 early refuse.

Taxon/occurrence[a]	**Common name**	**Part**	**SAC data**[b]	**New data**[c] **.71 mm**	**.25 mm**
		Charred botanical and nonbotanical remains			
Domesticated Plants					
Phaseolus vulgaris-type	common bean	cotyledon fragment	1	-	-
Zea mays	maize/corn	cupule	40	1	-
Zea mays	maize/corn	kernel	1	-	-
Zea mays	maize/corn	kernel fragment	22	-	-
Zea mays	maize/corn	kernel embryo	x†	-	-
Wild Plants					
Gymnosperms					
Juniperus osteosperma-type	Utah juniper	scale leaf	-	-	2
Juniperus-type	juniper	charcoal	14	-	-
Pinus-type	pine	bark scale	13	>11	>10
Pinus-type	pine	charcoal	1	-	-
Angiosperms					
Amaranthus-type	pigweed	seed	-	1	1
Angiosperm-type		pith	-	3	-
Artemisia tridentata-type	big sagebrush	charcoal	-	2	-
Portulaca retusa-type	purslane	seed	-	2	7
Portulaca retusa-type	purslane	seedcoat	-	-	3
Prunus/Rosa-type	chokecherry/rose	charcoal	1	-	-
Sand Canyon *Malva*-type	mallow	fruit schizocarp	-	1	-
Stipa/Oryzopsis hymenoides-type	Indian ricegrass	floret fragment	1	-	-
Unknown botanical					
Black spherical body			-	-	3
Bud	3 types		-	1	2
Organic material			10	-	-
Seed			-	-	1
Tissue (type 5)			-	-	2
Tissue (unknown-type)			-	1	4
Wood charcoal			-	>10	-
Nonbotanical					
Fecal pellet (termite)			-	-	>6
		Uncharred botanical and nonbotanical remains			
Unknown botanical					
Disseminule			-	>10	>2
Nonbotanical					
Fecal pellet (insect unknown)			-	>9	>8
Insect casing			-	>2	1
Insect cocoon			-	-	1
Insect part			-	1	2

Notes:

[a] “Occurrence” designates all those unidentified/unidentifiable materials that do not fit the “taxon” level of description.

[b] Based on data from Adams *et al.* (2007) and the Crow Canyon Archaeological Center Research Database (CCAC 2015a).

[c] Results of additional analysis in 2009, this author.

Appendix H: Accumulation/observation patterning and species-area curves, SC samples

Tables in this section reflect plotted data displayed on accompanying species-“area”/accumulation curves. The curves demonstrate accumulation patterns for previously unexamined residua from Sand Canyon Pueblo flotation/light fraction .71 mm and .25 mm samples.

Table H.1 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC1 (PD 609, FS 3).

Subsample no.[a]	**Taxa/Observation**	**Total[b]**
.71 mm portion		
Taxa (charred)		
.71-3	*Cercocarpus*-type charcoal	1
.71-4	*Artemisia tridentata*-type charcoal	1
.71-4	*Juniperus osteosperma*-type scale leaf	1
.71-6	*Artemisia tridentata*-type achene	1
.71-6	*Pinus*-type bark scale	1
Botanical (charred)		
.71-1	Angiosperm charcoal (lenticular surface)	>1
.71-1	Tissue, unknown	>1
.71-4	Angiosperm pith	1
.71-7	Tissue type 5	1
Nonbotanical/other (charred & uncharred: C or U)		
.71-1	Disseminule, unknown (U)	1
.71-1	Twig, unknown (U)	>1
.71-1	Gastropod (U)	1
.71-3	Fecal pellet (U)	1
.25 mm portion		
Taxa (charred)		
.25-8	*Portulaca retusa*-type seed	1
.25-30	Poaceae panicoid-type caryopsis	1
Botanical (charred)		
.25-1	Black spherical body (C)	2
.25-5	Seed, unknown (degraded)	1
.25-20	Bud, unknown	4
.25-21	Bud, unknown	2
.25-36	Seed coat, unknown	1
Nonbotanical/other (charred & uncharred: C or U)		
.25-1	Fecal pellet (U)	1
.25-1	Insect casing (U)	1
.25-1	Insect part (U)	1
.25-6	Mineral (U)	1
.25-24	Fiber, unknown (U)	1

Notes:
[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.
[b] Total reflects cumulative specimen counts for each individual subsample.
> Greater than the amount noted, but count discontinued at this point and total content unknown.

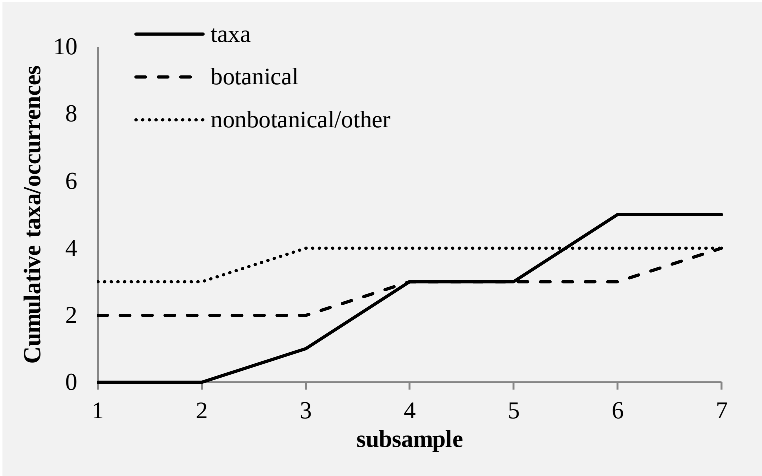


Figure H.1a Species accumulation curve accounting for new taxa, unique botanical and nonbotanical/other remains observed in the .71 mm residual portion of sample SC1 collected from the early temporal use of a courtyard firepit (feature 2) located in block 1000, Sand Canyon Pueblo.

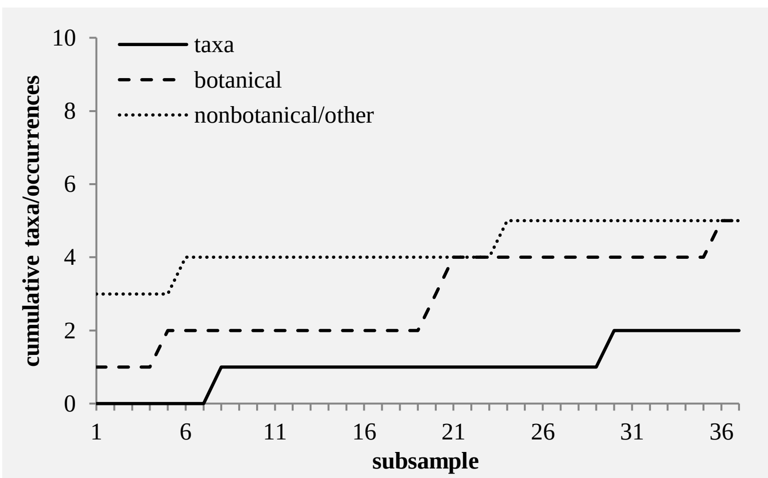


Figure 1 H.1b Species accumulation curve accounting for new taxa, unique botanical and nonbotanical/other remains observed in the .25 mm residual portion of sample SC1 collected from the early temporal use of a courtyard firepit (feature 2) located in block 1000, Sand Canyon Pueblo.

Table H.2 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC2 (PD 599, FS 3).

Subsample no.[a]	Taxa/Observation	Total[b]
.71 mm portion		
Taxa (charred)		
.71-1	*Artemisia tridentata*-type charcoal	3
.71-2	*Amaranthus*-type seed	1
.71-3	Monocotyledon-type stem segment	1
.71-3	Sand Canyon *Malva*-type fruit schizocarp	1
Botanical (charred)		
.71-1	Leaf fragment, unknown	1
.71-1	Tissue, nodulose-type	3
.71-1	Charcoal (lenticular surface)	>7
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Poaceae floret (U)	>1
.71-1	Disseminule (U)	>1
.71-1	Bone (C)	1
.71-1	Insect part (U)	1
.71-2	Cheno-am seed (U)	1
.71-3	Seed coat, unknown (U)	1
.71-4	Fecal pellet (C)	1
.71-4	Insect part (C)	2
.25 mm portion		
Taxa (charred)		
.25-1	Cheno-am seed	1
.25-24	*Portulaca retusa*-type seed	1
Botanical (charred)		
.25-2	Angiosperm charcoal (lenticular surface)	>1
.25-6	Black spherical body (C)	1
.25-8	Tissue, type 5	5
.25-16	Seed, unknown (highly degraded)	2
Nonbotanical/Other (charred & uncharred/C or U)		
.25-1	Bone, unknown (U)	1
.25-1	Insect casing (U)	1
.25-3	Fecal pellet (U)	1
.25-4	Fiber (modern)(U)	2
.25-8	*Portulaca retusa* seed coat (U)	1
.25-12	Insect casing (C)	3
.25-17	Hair (U)	1

Notes:
[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.
[b] Total reflects cumulative specimen counts for identified subsample.
> Greater than the amount noted, but count discontinued at this point and total content unknown.

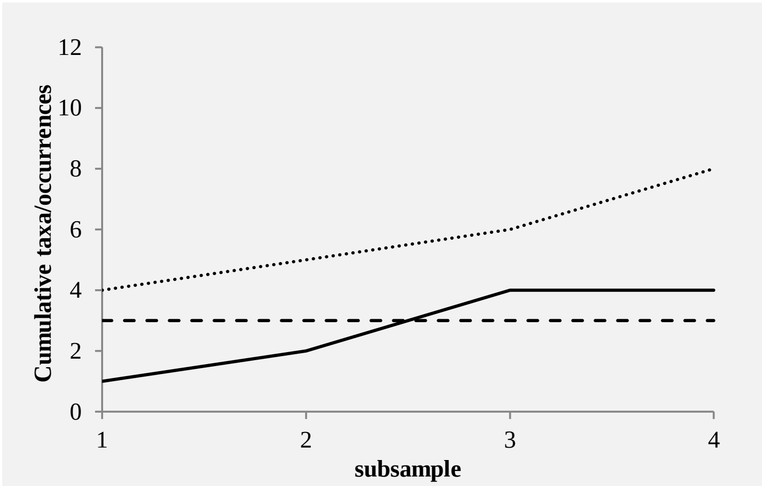


Figure 2 H.2a Species accumulation curve accounting for new taxa, unique botanical and nonbotanical/other remains observed in the .71 mm residual portion of sample SC2 collected from one of three firepits (feature 2) located in room 1002, block 1000, Sand Canyon Pueblo. Temporal use of the feature is associated with abandonment or latest occupation activities.

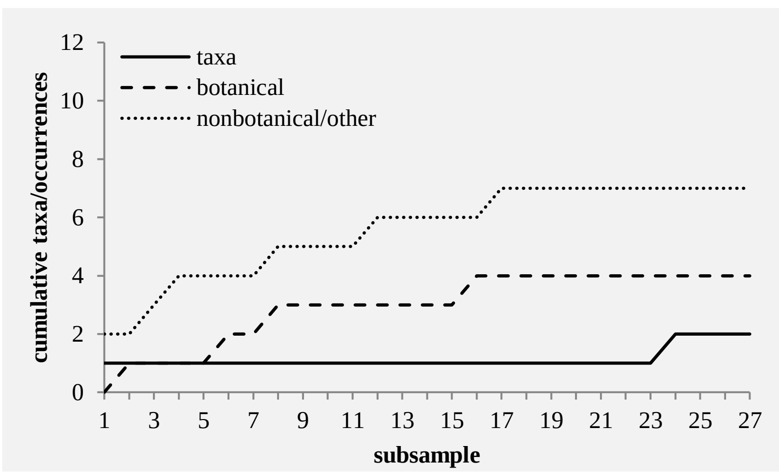


Figure 3 H.2b Species accumulation curve accounting for new taxa, unique botanical and nonbotanical/other remains observed in the .25 mm residual portion of sample SC2 collected from one of three firepits (feature 2) located in room 1002, block 1000, Sand Canyon Pueblo. Temporal use of the feature is associated with abandonment or latest occupation activities.

Table H.3 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC3 (PD 1543, FS 1).

Subsample no.[a]	Taxa/Occurrences	Total[b]
.71 mm portion		
Taxa (charred)		
.71-1	*Zea mays* kernel embryo	2
.71-2	*Zea mays* glume whole/fragment	1
.71-2	*Artemisia tridentata*-type flowering head	1
.71-3	Cheno-am seed	1
.71-5	*Bromus*-type grass caryopsis	1
.71-5	*Quercus*-type (cf) charcoal	1
Botanical (charred)		
.71-1	Angiosperm charcoal, unknown (lenticular surface)	>1
.71-1	Tissue, type 5	>1
.71-1	Tissue, vitrified	1
.71-1	Bud, unknown	1
.71-1	Gymnosperm charcoal, unknown	1
.71-2	Black spherical body	1
.71-2	Tissue, parenchyma	3
.71-3	Tissue, unknown	>1
.71-3	Tissue, epidermis	>1
.71-6	Leaf, unknown	1
.71-9	Bark fragment, unknown	1
.71-10	Bud, unknown	1
.71-11	Tissue, rugulose	1
.71-13	Bud, unknown	2
Nonbotanical/Other (charred & uncharred/U or C)		
.71-1	Twig unknown (U)	>1
.71-1	Adobe fragment (U)	1
.71-1	Fecal pellet (C)	1
.71-1	Insect part (U)	1
.71-1	Tissue, unknown (modern?)(U)	>1
.71-1	Fecal pellet (U)	>1
.71-5	Cheno-am seed (U)	1
.71-6	Black spherical body (U)	2
.71-9	*Physalis longifolia*-type (U)	1
.71-11	Fibers, unknown (pink & blue)(U)	2
.25 mm portion		
Taxa (charred)		
.25-10	Poaceae-type caryopsis	1
.25-12	Poaceae-type floret	1
.25-20	*Portulaca retusa*-type seed	1
Botanical (charred)		
.25-1	Bud, unknown	1
.25-3	Bud, unknown	1
.25-11	Bud, unknown	1
.25-16	Leaf, unknown	1
.25-19	Bud, unknown	1

continued.

Table H.3 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC3 (PD 1543, FS 1), continued.

Subsample no.[a]	Taxa/Occurrences	Total[b]
Nonbotanical/Other (charred & uncharred/C or U)		
.25-3	Insect casing (U)	1
.25-5	Insect part (C)	1
.25-5	Cheno-am immature interior (U)	1
.25.6	Hair (U)	1
.25-7	*Portulaca retusa* seed (U)	1
.25-9	Fecal pellet (>.71-mm)(U)	1
.25-10	Gastropod, unknown (U)	1
.25-11	Insect casing (C)	2
.25-14	Disseminule (U)	1
.25-17	Cheno-am seed coat (U)	1

Notes:
[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.
[b] Total reflects cumulative specimen counts for identified subsample.
> Greater than the amount noted, but count discontinued at this point and total content unknown.

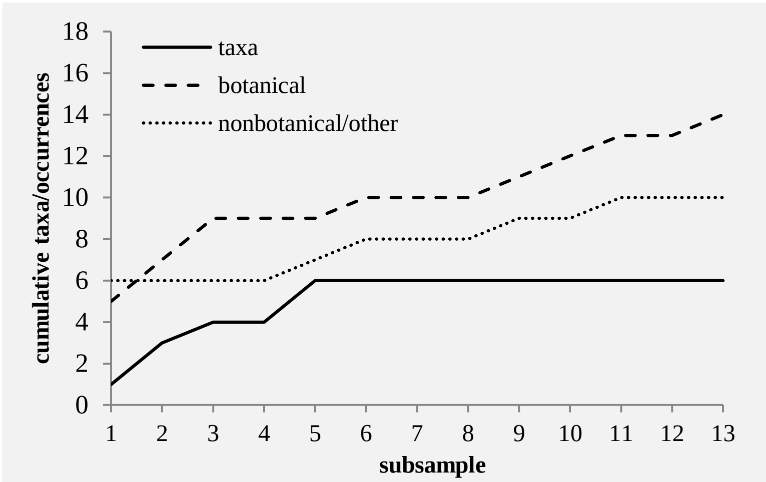


Figure 4 H.3a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC3 from a firepit located in the upper story of west kiva (1502) corner room 1527, D-shaped Building, Sand Canyon Pueblo.

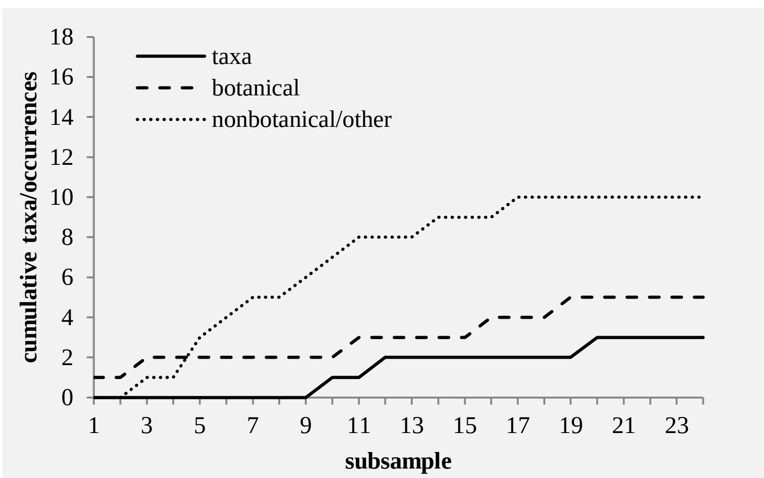


Figure 5 H.3b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC3 from a firepit located in the upper story of west kiva (1502) corner room 1527, D-shaped Building, Sand Canyon Pueblo.

Table H.4 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC4 (PD 147, FS 4).

Subsample no.[a]	Taxa/Occurrences	Total[b]
.71 mm portion		
Taxa (charred)		
.71-1	*Physalis longifolia*-type seed	1
.71-3	*Artemisia tridendata*-type (cf) charcoal	1
.71-3	*Portulaca retusa*-type seed	1
.71-7	*Nicotiana*-type seed	1
.71-11	Cheno-am seed	1
.71-13	*Juniperus osteosperma*-type twig	1
Botanical (charred)		
.71-1	Charcoal, unknown	>1
.71-1	Bud, unknown	1
.71-3	Leaf, unknown	1
.71-6	Bud, unknown	1
.71-6	Tissue, unknown	2
.71-10	Gymnosperm, unknown	1
.71-14	Angiosperm, unknown (lenticular surface)	1
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Disseminule, unknown (U)	>1
.71-1	Black spherical body (C)	1
.71-8	Fecal pellet, unknown (U)	2
.71-17	Insect casing, unknown (U)	1
.25 mm portion		
Taxa (charred)		
.25-17	Monocotyledon-type fibrovascular bundle	1
Botanical (charred)		
.25-1	Charcoal, unknown	>1
.25-4	Black spherical body	1
.25-13	Bud, unknown (overwintering)	1
Nonbotanical/Other (charred & uncharred/C or U)		
.25-1	Insect part (U)	1
.25-12	Insect part (C)	1
.25-17	Bone (C)	1

Notes:

[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.

[b] Total reflects cumulative specimen counts for identified subsample.

\> Greater than the amount noted, but count discontinued at this point and total content unknown.

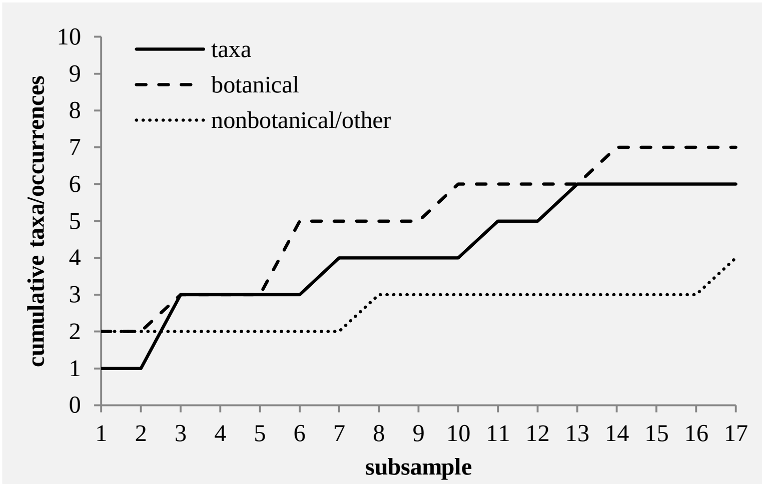


Figure 6 H.4a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC4 from the hearth located in the "*Cleome*" kiva (kiva 102), block 100, Sand Canyon Pueblo.

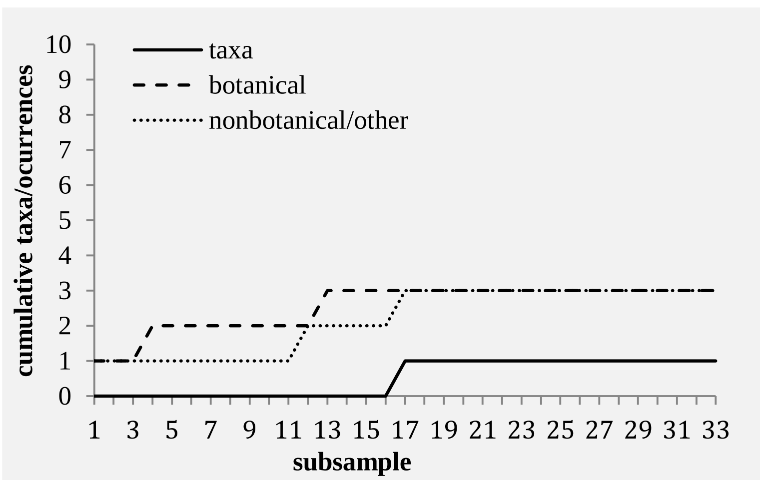


Figure 7 H.4b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC4 from the hearth located in the "*Cleome*" kiva (kiva 102), block 100, Sand Canyon Pueblo.

Table H. 5 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC5 (PD 1582, FS 4).

Subsample no.[a]	**Taxa/Occurrences**	**Total**[b]
.71 mm portion		
Taxa (charred)		
.71-2	*Cercocarpus* charcoal	1
.71-3	*Juniperus osteosperma*-type scale leaf/twigs	>3
Botanical (charred)		
.71-4	Tissue, vitrified	1
.71-5	Bud, unknown	1
.71-6	Tissue, unknown	3
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Disseminule (U)	>1
.71-4	Fecal pellet (U)	1
.25 mm portion		
Taxa (charred)		
.25-1	Cheno-am seed	1
Botanical (charred)		
.25-2	Charcoal, unknown	>1
.25-8	Disseminule, unknown	1
Nonbotanical/Other (charred & uncharred/C or U)		
.25-1	Disseminule, unknown (U)	>1
.25-1	Bone (C)	>1
.25-1	Insect casing (U)	1
.25-3	Insect casing (C)	1
.25-5	Insect part (C)	>1

Notes:

[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.

[b] Total reflects cumulative specimen counts for identified subsample.

\> Greater than the amount noted, but count discontinued at this point and total content unknown.

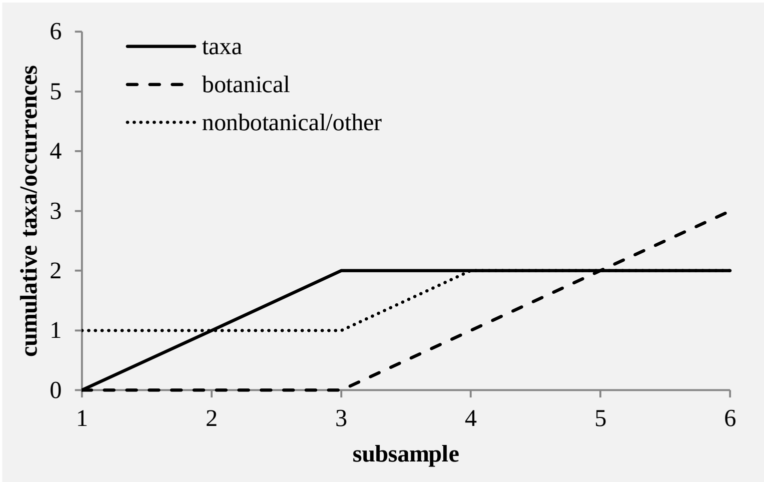


Figure 8 H.5a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC5 from the hearth located in test trench kiva 600, Sand Canyon Pueblo.

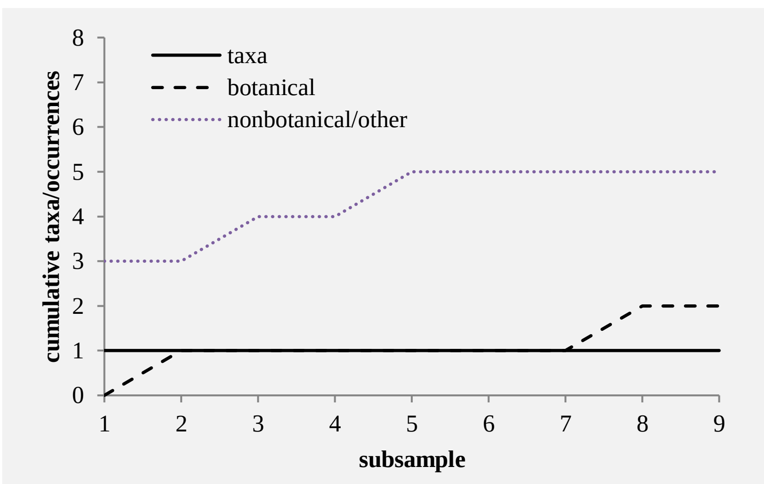


Figure 9 H.5b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC5 from the hearth located in test trench kiva 600, Sand Canyon Pueblo.

Table H.6 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC6 (PD 786, FS 8).

Subsample no.[a]	Taxa/Occurrences	Total[b]
.71 mm portion		
Taxa (charred)		
.71-3	Poaceae (festucoid-type) caryopsis	1
Botanical (charred)		
.71-2	Bud, unknown	1
.71-2	Disseminule, unknown	1
.71-4	Tissue, unknown	1
.71-5	Black spherical body (C)	1
.71-5	Bud, unknown	1
.71-5	Tissue, epidermis	1
.71-5	Tissue, parenchyma	1
.71-5	Seed fragment, unknown	1
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Fecal pellet (U)	>1
.71-1	*Juniperus osteosperma*-type twig (U)	1
.71-2	Poaceae, festucoid-type caryopsis (U)	>1
.71-4	White spherical body (U)	1
.71-4	Seed, immature, ovoid, *croton*-like (U)	1
.71-4	Seed, immature, round, unknown (U)	2
.71-5	Insect cocoon (U)	1
.25 mm portion		
Taxa (charred)		
-	-	-
Botanical (charred)		
.25-1	Black spherical body (U)	>1
.25-5	Bud, unknown	1
Nonbotanical/Other (charred & uncharred/C or U)		
.25-1	Fecal pellet (U)	>1
.25-3	Black spherical body (C)	>1
.25-3	White spherical body (U)	>1
.25-4	Insect part (C)	1
.25-4	Poaceae, festucoid-type caryopsis (U)	1
.25-4	Unknown	1

Notes:
[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.
[b] Total reflects cumulative specimen counts for identified subsample.
> Greater than the amount noted, but count discontinued at this point and total content unknown.

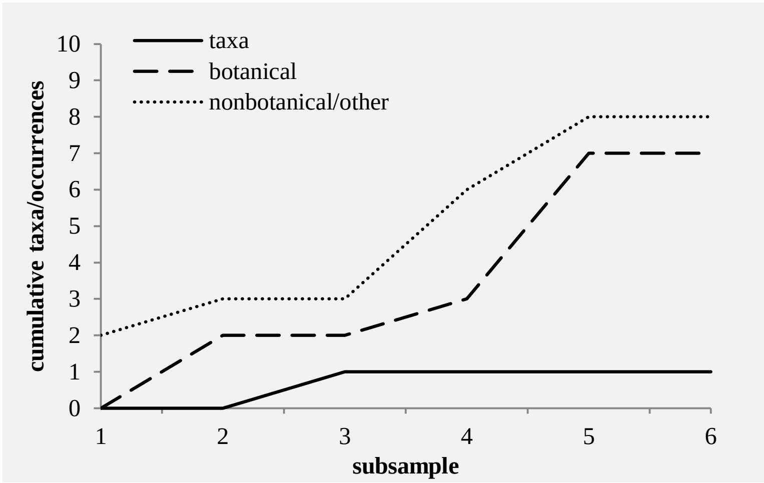


Figure 10 H.6a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC6 from midden 109 block 100, Sand Canyon Pueblo.

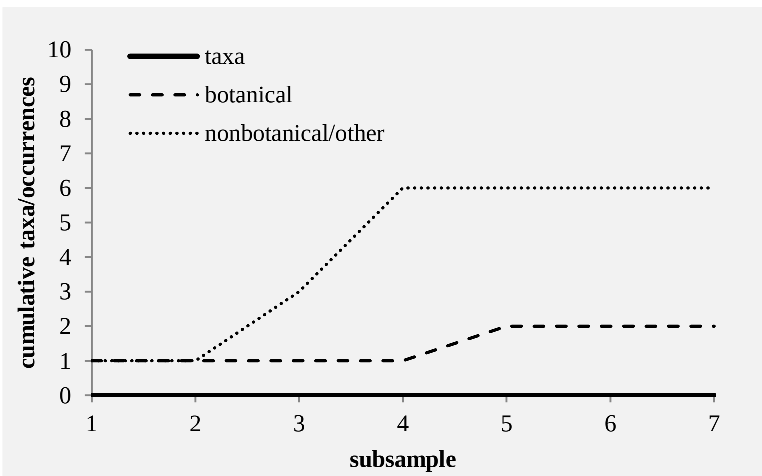


Figure H.6b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC6 from midden 109 block 100, Sand Canyon Pueblo.

Table H.7 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC7 (PD 701, FS 41).

Subsample no.[a]	Taxa/Occurrences	Total[b]
.71 mm portion		
Taxa (charred)		
.71-2	*Pinus*-type bark scale	>1
.71-4	*Chenopodium*-type seed	1
Botanical (charred)		
.71	Nil	-
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Cheno-am/Chenopodium seed, seed coat (U)	>1
.71-1	Disseminule (U)	1
.71-1	Fecal pellet (U)	>1
.71-6	Insect part (U)	>1
.71-9	Insect cocoon (U)	1
.25 mm portion		
Taxa (charred)		
.71-4	*Portulaca retusa*-type seed	2
Botanical (charred)		
.25-1	Black spherical body (C)	>1
.25-7	Disseminule, unknown (C)	>1
Nonbotanical/Other (charred & uncharred/C or U)		
.25-5	Fecal pellet (C)	
.25-6	Insect casing (U)	1
.25-6	Termite fecal pellet (C)	1

Notes:
[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number
[b] Total reflects cumulative specimen counts for identified subsample.
> Greater than the amount noted, but count discontinued at this point and total content unknown.

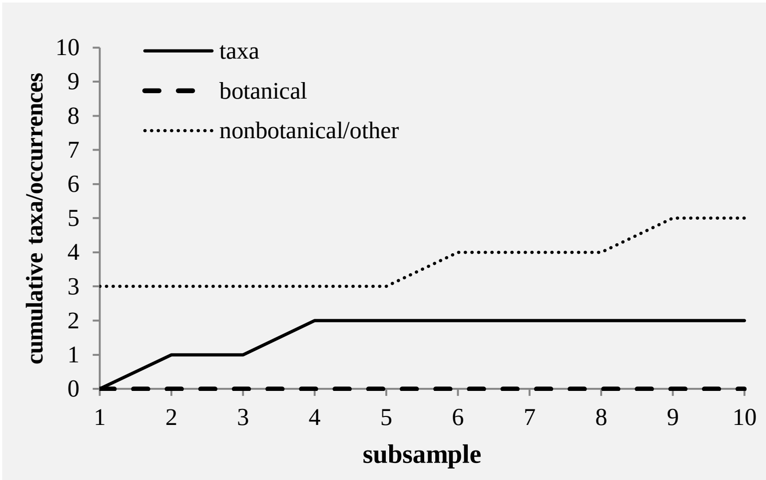


Figure 11 H.7a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC7 from midden 515, block 500, Sand Canyon Pueblo.

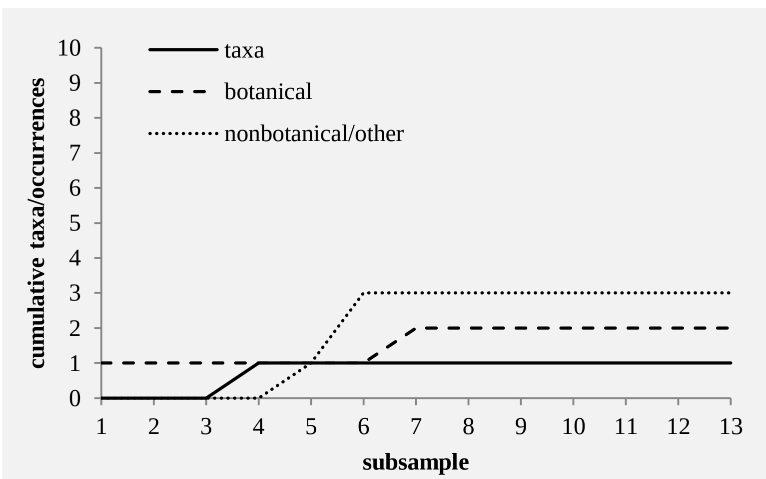


Figure 12 H.7b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC8 from midden 515, block 500, Sand Canyon Pueblo.

Table H.8 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC8 (PD 1008, FS 113).

Subsample no.[a]	Taxa/Occurrences	Total[b]
.71 mm portion		
Taxa (charred)		
.71-1	*Chrysothamnus*-type (cf) charcoal	1
.71-1	*Pinus edulis*-type needle fragment	3
.71-3	*Juniperus osteosperma*-type scale leaf	1
.71-5	Monocotyledon-type stem pith	1
Botanical (charred)		
.71-1	Charcoal, unknown	>1
.71-1	Angiosperm charcoal (lenticular surface)	>1
.71-1	Seed, unknown (fragment)	1
.71-2	Disseminule, unknown	1
.71-3	Bud, unknown	1
.71-4	Black spherical body (C)	1
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Disseminule (U)	>1
.71-2	Fecal pellet (U)	6
.71-4	Insect casing (U)	1
.71-4	Bone (U)	1
.71-5	Insect part (C)	6
.71-5	Insect part (U)	5
.25 mm portion		
Taxa (charred)		
Nil	-	-
Botanical (charred)		
.25-1	Tissue, nodulose-type	1
.25-6	Bud, unknown	1
.25-6	Tissue, unknown	1
.25-9	Tissue, epidermis	1
.25-11	Seed-like tissue (fragmented)	1
Nonbotanical/Other (charred & uncharred/C or U)		
.25-4	Fecal pellet (U)(4 different types)	15
.25-5	Termite fecal pellet (C)	1
.25-8	*Portulaca retusa*-type seed (U)	1
.25-10	Insect cocoon (U)	1
.25-10	Cheno-am seed (U)	1

Notes:

[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.

[b] Total reflects cumulative specimen counts for identified subsample.

> Greater than the amount noted, but count discontinued at this point and total content unknown.

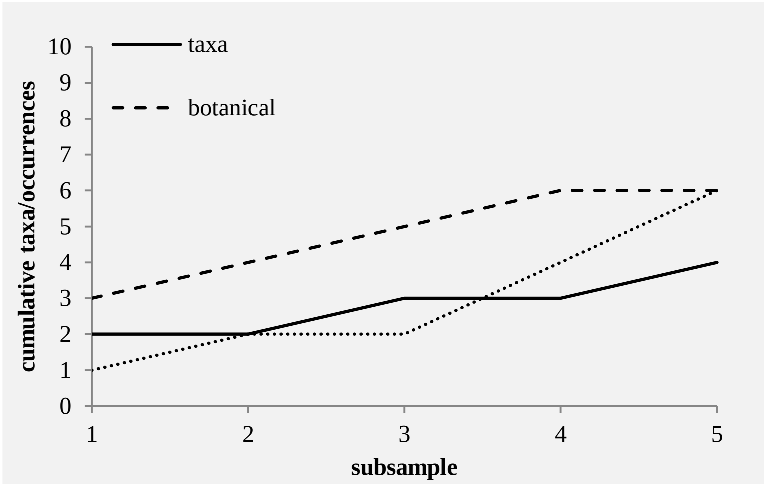


Figure 13 H.8a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC8 from great kiva trash (nonstructure 803), block 800, Sand Canyon Pueblo.

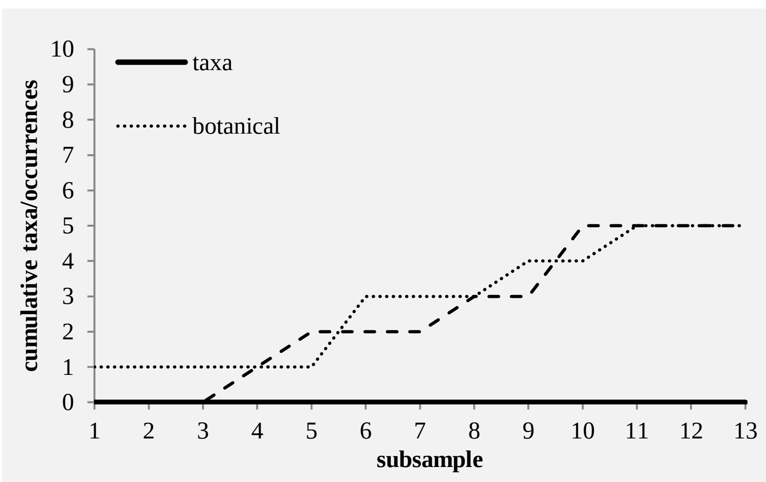


Figure 14 H.8b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC8 from great kiva trash (nonstructure 803), block 800, Sand Canyon Pueblo.

Table H.9 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC9 (PD 357, FS 51).

Subsample no.[a]	Taxa/Occurrences	Total[b]
.71 mm portion		
Taxa (charred)		
.71-1	*Pinus edulis*-type needle fragment	1
.71-3	*Amaranthus*-type seed	1
.71-3	*Eleocharis*-type achene/seed	1
.71-4	*Chenopodium*-type seed	1
.71-4	Poaceae (unknown type) stem fragment	1
.71-5	*Nicotiana*-type seed coat	1
.71-7	Poaceae (type B) stem segment	1
.71-7	*Vaccaria*-type seed coat	1
.71-16	Poaceae (festucoid-type) caryopsis	1
.71-18	*Artemisia tridentata*-type achene	1
Botanical (charred)		
.71-1	Black spherical body (C)	1
.71-1	Tissue, unknown	1
.71-1	Tissue, type 5	1
.71-3	Seed, *Alyssum*-like, unknown	1
.71-7	Tissue, nodulose-type	2
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Bone (U)	1
.71-1	Insect casing (U)	2
.71-1	Mineral, Ferrian illite/glauconite (U)	2
.71-2	Cheno-am immature seed interior (U)	4
.71-7	Fecal pellet (C)	>1
.71-9	Insect part (U)	1
.71-10	Insect part (C)	1
.71-15	Fecal pellet (U)	1
.25 mm portion		
Taxa (charred)		
.25-1	Poaceae (type A) stem fragment	>3
.25-4	Poaceae (type D) stem segment	1
.25-16	Monocotyledon-type fibrovascular bundle	1
.25-18	Cyperaceae-type stem segment	1
.25-22	*Polanisia*-type seed coat	1
.25-52	*Ceratoides lanata*-type (cf) twig fragment	1
Botanical (charred)		
.25-22	Flowering head, unknown	1
.25-33	Seed coat, unknown	1
.25-40	Seed fragment, unknown	1
.25-40	Seed coat, unknown	1
.25-47	Tissue, vitrified	1
.25-52	Botanical, unknown	1

continued…

Table H.9 Distribution of diversity in .71 and .25 mm portions on re-analysis, sample SC9 (PD 357, FS 51), continued.

Subsample no.[a]	Taxa/Occurrences	Total[b]
.25 mm portion continued		
Nonbotanical/Other (charred & uncharred/C or U)		
.25-1	Mineral: quartz (U)	1
.25-1	Fiber, unknown (U), modern	1
.25-10	Termite fecal pellet (C)	1
.25-22	Bone (C)	1
.25-24	Disseminule (U)	1
.25-52	Insect casing (C)	1

Notes:

[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number.

[b] Total reflects cumulative specimen counts for identified subsample.

> Greater than the amount noted, but count discontinued at this point and total content unknown.

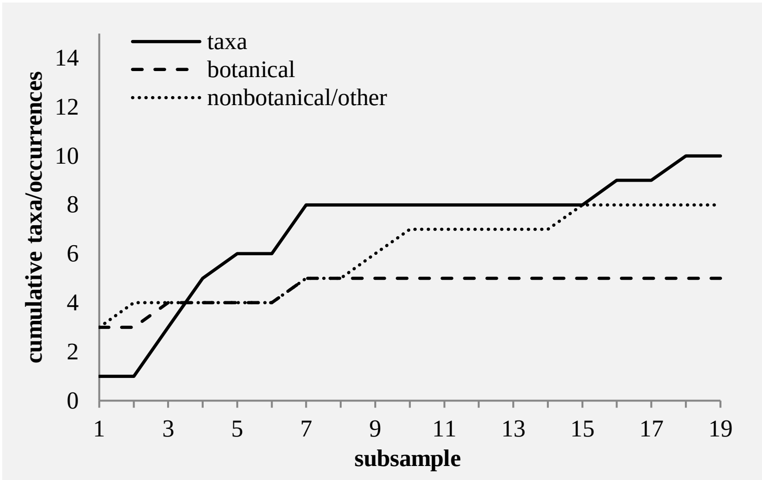


Figure 15 H.9a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC9 from midden 1214 block 1200, Sand Canyon Pueblo.

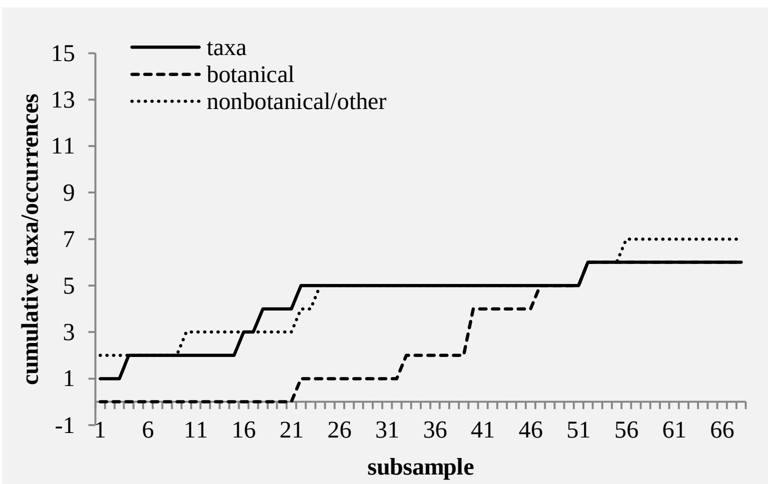


Figure 16 H.9b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC9 from trash midden 1214 block 1200, Sand Canyon Pueblo.

Table H.10 Distribution of new diversity in .71 and .25 mm portions on re-analysis, sample SC10 (PD 715, FS 5).

Subsample no.[a]	**Taxa/Occurrences**	**Total**[b]
.71 mm portion		
Taxa (charred)		
.71-1	*Artemisia tridentata*-type (cf) charcoal	1
.71-1	*Portulaca retusa*-type seed	2
.71-2	Sand Canyon *Malva*-type fruit schizocarp	1
.71-9	*Amaranthus*-type seed	1
Botanical (charred)		
.71-1	Bud, unknown	1
.71-1	Charcoal, unknown	>1
.71-3	Angiosperm pith, unknown	1
.71-3	Tissue, unknown	1
Nonbotanical/Other (charred & uncharred/C or U)		
.71-1	Disseminule (U)	>1
.71-1	Fecal pellet (U)	>1
.71-2	Insect part (U)	>1
.71-8	Insect casing (U)	1
.25 mm portion		
Taxa (charred)		
.25-2	*Juniperus osteosperma*-type scale leaf	1
Botanical (charred)		
.25-5	Black spherical body	1
.25-6	Bud, unknown	1
.25-7	Seed fragment, unknown	1
.25-11	Bud, unknown	1
.25-13	Tissue, type 5	2
Nonbotanical/Other (charred & uncharred/C or U)		
.25-3	Termite fecal pellet (C)	>1
.25-5	Black spherical body (C)	1
.25-5	Insect part (U)	1
.25-10	Insect cocoon (U)	1

Notes:

[a] Subsample number consists of size screen (e.g. .71) followed by the actual subsample number

[b] Total reflects cumulative specimen counts for identified subsample.

> Greater than the amount noted, but count discontinued at this point and total content unknown.

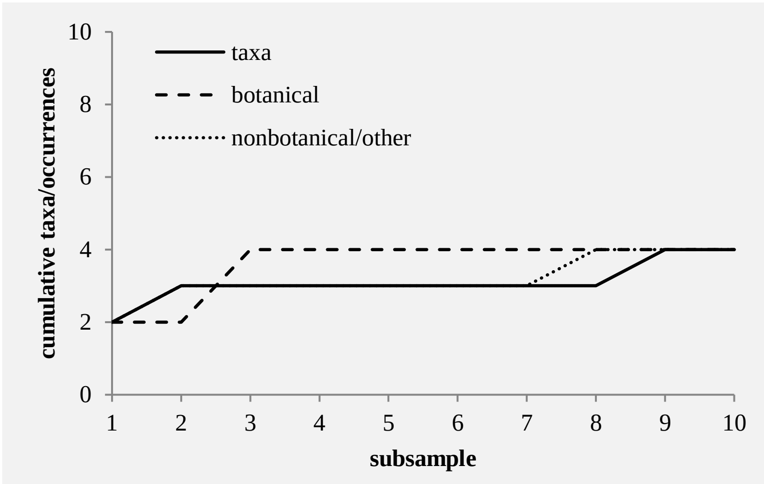


Figure 17 H.10a Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .71 mm residual portion of sample SC9 from pre-A.D. 1252 courtyard refuse surrounding the subterranean kiva in block 500, Sand Canyon Pueblo.

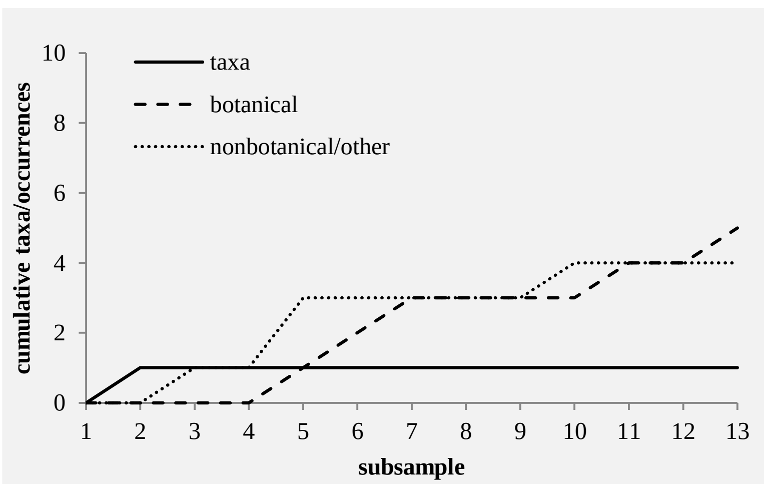


Figure 18 H.10b Species accumulation curve accounting for new taxa, botanical and nonbotanical/other remains for the .25 mm residual portion of sample SC9 from pre-A.D. 1252 courtyard refuse surrounding the subterranean kiva in block 500, Sand Canyon Pueblo.