A PREDICTIVE MODELING AND ECOCULTURAL STUDY OF PINE MUSHROOMS (*TRICHOLOMA MURRILLIANUM*) WITH THE LÍL̓WAT NATION IN BRITISH COLUMBIA, CANADA

by

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Abstract

Although recognized by the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), Indigenous rights to traditionally held and managed forestlands and forest resources are only beginning to gain visibility in forest research and management in Canada. This presents challenges to First Nations whose cultural and economic priorities for forest use conflict with those of private and public entities, particularly when evidence is required to support traditional use claims. Knowledge of traditional use is customarily maintained as oral history and is rarely available in formats recognized by Canadian legal and governance institutions. Such is the case with the Líl̓wat First Nation, in British Columbia, Canada, and *Tricholoma murrillianum* (pine mushroom), an elusive, ectomycorrhizal mushroom species whose value to Líl̓wat people is put at risk by competing timber interests. Rich Líl̓wat Indigenous knowledge (IK) of pine mushrooms signals their importance and is encoded in temporally long and detailed records of their presence on the landscape. I elicit Líl̓wat IK to generate a map of pine mushroom habitat in their traditional territory and demonstrate the multifaceted value of pine mushrooms to Líl̓wat people. I utilize the species distribution modeling (SDM) software Maxent to compare two methods for incorporating Líl̓wat IK to produce pine mushroom occurrence data, yielding two models of suitable habitat. I demonstrate that Líl̓wat IK generates species distribution models with high area under the curve values (0.920, 0.923) and low omission error rates (0.054, 0.062). This study also demonstrates the novel application of IK to fungi SDM. Drawing from semi-structured interviews, document analysis and discourse analysis, I show that harvesting pine mushrooms is an expression of Líl̓wat cultural revitalization and consequently, colonial resistance. Documented traditional Líl̓wat practices show that pine mushrooms have long been managed in relation to other species, such as deer, and as part of broader sociocultural systems founded in reciprocity. Where Western scientists are increasingly interested in working with Indigenous communities and IK, I highlight respectful and reciprocal ways in which ecological and ethnoecological research can be undertaken.

Lay Summary

In Canada, First Nations do not yet have full decision-making authority over forests in their traditional territories. Consequently, when First Nations cultural and economic interests conflict with the timber interests of private companies and government, First Nations must often prove through the Canadian legal system that their historical and ongoing use of the land takes precedent. My research provided the Líl̓wat First Nation in British Columbia with evidence of their long-standing tradition of gathering and managing pine mushrooms, which cannot grow without certain species of live trees nearby. I worked with Líl̓wat mushroom pickers to find pine mushrooms, and combined this Indigenous knowledge with computer software to predict and map where pine mushrooms are most likely to grow. Interviews with Líl̓wat people revealed that for many people, harvesting mushrooms is a way of strengthening connections to their culture and healing the effects of colonialism, affirming their importance beyond economic value.

Preface

Líl̓wat Nation staff commissioned chapter 2 of this thesis, with introductions facilitated by PhD candidate, Ms. Tonya Smith. Research objectives for this chapter were co-defined with Mr. Jordon Gabriel of Líl̓wat Nation, and under the guidance of my co-supervisor Dr. Jeanine Rhemtulla, with whom I also co-designed the methods. Emily Doyle-Yamaguchi and Mr. Gabriel led field data collection. Additional data were obtained from publicly available datasets. Analysis and writing were completed by Emily Doyle-Yamaguchi, with significant editorial contributions and technical guidance from Dr. Rhemtulla. Dr. Nicholas Coops provided additional technical supervisory and editorial support for this chapter.

Research objectives and interview questions for Chapter 3 of this thesis were co-defined with Mr. Gabriel and under the guidance of my co-supervisor, Dr. Janette Bulkan. Dr. Bulkan also advised on methods and methodologies, and provided significant editorial contributions to the writing. Analysis was completed by Emily Doyle-Yamaguchi.

On March 8, 2019, an outline of this research project was presented to and approved by the Líl̓wat Culture Heritage and Language Authority, subject to conformance with the S7istken Líl̓wat Research Protocol. A Certificate of Approval was issued by the UBC Behavioural Research and Ethics Board on July 12, 2019 and renewed on May 19, 2020 under ID H19-01554-A003.

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As I reflect on the many people without whom this thesis would not have been possible, I remember the words of scholar Louise Fortmann: “[t]he people we work with in the field literally give us our careers” (Fortmann, 2014, p. 2) . To that end, I owe more than I can express to Jordon Gabriel and Martin Nelson, in particular, who were my teachers, guides, and friends throughout this research project. I am in awe of your leadership, commitment to authenticity, and love for your territory. Tonya Smith, thank you for introductions to so many wonderful people in the Líl̓wat community, for your guidance and your friendship. Dr. Jeanine Rhemtulla and Dr. Janette Bulkan, your dedication to your students and pursuit of a more resilient and compassionate world through scholarship are an inspiration. Thank you for taking me under your wings. Dr. Nicholas Coops, thank you for your support and excellent editorial guidance.

I thank the members of the Líl̓wat Culture, Heritage and Language Authority—guardians of Líl̓wat interests with respect to research, and intellectual property—for allowing me the chance to do this work and trusting me to do so. Gélpcal Chief Ashley Joseph, thank you as well for your trust, and for supporting this project so enthusiastically. Jeanie Andrews, I am grateful for your teachings and friendship, and hope to have many more opportunities to share laughter and time on the land. Harriet VanWart and Klay Tindall, your contributions of staff time, resources and guidance are deeply appreciated.

Scholarship is a privilege and I owe this opportunity to many: my mother, Cathy—you followed your own path so I could as well; my father, Yaz—your unwavering belief in me gave me so much courage; my partner, Andrew—thank you for your unconditional love and patience; the Tresters—I am ever grateful for your excellent care. Every single person before me to have pushed the academic limits of their time—women, people of colour, freethinkers—thank you. It is because of your hard-won efforts and refusal to accept the status quo that I have the latitude to be myself within the halls of academia. I only hope that my work can do the same for others.

I acknowledge the funding from Social Sciences and Humanities Research Council Insight Grant # 435-2017-0287, which made my research possible.

Dedication

I dedicate this thesis to the 17 Lillooet Chiefs who, in 1911, issued the Declaration of the Lillooet Tribes. In this era of reconciliation, lest we forget the truth of our history as a province and country:

“We are aware the B.C. government claims our country, like all other Indian territories in B.C.; but we deny their right to it. We never gave it nor sold it to them. They certainly never got the title to the country from us, neither by agreement nor conquest, and none other than us could have any right to give them title” (Chiefs of the Lillooet Tribe, 1911).

Chapter 1: Introduction

Over one third of intact forest landscapes worldwide are within Indigenous Peoples' (IP) lands (Fa et al., 2020), with increasing evidence of correspondingly higher levels of biological diversity (Schuster, Germain, Bennett, Reo, & Arcese, 2019). In addition to conserving biodiversity, intact forests play a critical role in storing carbon, mitigating a wide range of climate change effects, from fire and flooding to infectious diseases, and providing the material and cultural resources essential to Indigenous culture and livelihoods (J. E. M. Watson et al., 2018). The integrity of intact forests is thus both an outcome, and determinant, of Indigenous forest stewardship.

The rights of IPs to "own, use, develop and control" traditionally held or managed forestlands and resources are recognized in Articles 25 and 26 of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) (UN General Assembly, 2007). Canada, which contains almost ten percent of the world's forests (Natural Resources Canada, 2020), initially voted against the adoption of UNDRIP, with almost a decade passing before a national commitment was made to "full and effective implementation" (Department of Justice Canada, 2020). Entirely or largely excluded from forest decision-making until recent decades, the notion of "Aboriginal forestry" or "Indigenous forestry"[1] has slowly emerged in Canada to reflect varying degrees of involvement by IPs in managing their traditionally held forestlands (Bulkan, 2017; Wyatt, 2008). Forestry *by* and *for* First Nations is most common, where First Nations may have greater access to forestry jobs, economic benefits, and/or tenure, but none providing true opportunities for increased control by IPs over forest management, or the articulation of Indigenous rights within existing institutional and planning frameworks (Ibid). In contrast, Wyatt (2008) argues that a forest management system truly representative of "Aboriginal forestry" is one where First Nations hold permitting and veto authority, traditional protocols are observed during consultation, and forest professionals are equally required to train in aboriginal forest management systems as in non-aboriginal management systems (Ibid).

[1] Unless otherwise specified, I use the terms "Aboriginal" and "Indigenous" synonymously in reference to the ancestry and cultural practices of the original peoples of Canada. Under the *Canadian Constitution Act* of 1982, the term "Aboriginal" is inclusive of "Indian, Inuit and Métis peoples of Canada". The term "Indigenous" is increasingly preferred in both form and informal settings in Canada, however it is also legally defined in international policy, such as the United Nations Declaration on the Rights of Indigenous Peoples.

Achieving literacy in “Aboriginal forestry” requires that forest managers develop an understanding of the ecocultural connections between IPs and their traditionally held and managed forest landscapes. The terms “ecoculture” and “ecocultural” were proposed to explicitly acknowledge the ways in which ecosystems both influence and are influenced by cultural values and practices (Pretty, 2011). Indigenous knowledge (IK) results from immersion within ecocultural systems, articulated as place-based knowledge and “sets of practices” (Peloquin & Berkes, 2009, p. 534) designed to manage land as “an integral part of one’s whole existence” (Kayahara & Armstrong, 2015, p.131). While forest researchers and land managers are increasingly recognizing the critical role of Indigenous land stewardship in maintaining forest health and productivity (Anderson & Lake, 2013b; Armstrong, Miller, Mcalvay, Ritchie, & Lepofsky, 2021; Johnson, 2013), few specific practices have been incorporated into dominant forest management systems. Canadian forest management is largely focused on economic development, and current forest tenure and management policies are not well suited to meet non-economic goals, such as cultural identity and reciprocity, which may be equally or more important to Indigenous communities (Beaudoin et al., 2016). Thus “Aboriginal forestry”, as described by Wyatt (2008), continues to exist at the margins of conventional forest management in Canada, as do Indigenous theories and approaches within the forestry literature (Mcgregor, 2010). A paradigm shift towards forest management founded in customary stewardship requires the integration not only of IK, but of the larger ecocultural system in which IK is embedded (O’Flaherty, Davidson-Hunt, & Miller, 2009).

1.1. Research Objectives

In this thesis, I investigate the ecocultural system of pine mushrooms (*Tricholoma murrillianum*) within the context of the Líl̓wat Nation’s Indigenous forest stewardship. I use a case study of pine mushrooms and Líl̓wat Nation in order to contribute to the body of knowledge in ecocultural forestry and to argue for a richer, more complex understanding of forest management in relation to Indigenous values. The specific goals of my research were:

1) to collaborate with and support the Líl̓wat Nation in their efforts to steward pine mushroom habitat in their traditional territory[2];

[2] I use the term “traditional territory” according to the definition “the geographic area identified by a First Nation as the land they and their ancestors traditionally occupied and used” (Wilson, 2018, p. 92).

2) to test the use of Indigenous knowledge in species distribution modelling;
3) to explore the value of pine mushrooms to Líl̓wat people, as articulated by harvesting and stewardship practices; and
4) to engage respectfully and reciprocally with Líl̓wat people and Líl̓wat knowledge.

In chapter 2, I fulfill goals 1) and 2) by comparing two methods for incorporating IK in pine mushroom species distribution modeling (SDM), using the software Maxent (S. J. Phillips, Anderson, & Schapire, 2006). The first method uses IK to locate and record pine mushroom occurrences in the field. The second method uses oral IK in place of field data to approximate and locate occurrences on a map. I conclude that IK can be used in place of occurrence records collected in the field to generate habitat models with high discriminatory power and low error rates.

In chapter 3, I fulfill goal 3. I use qualitative methods and triangulate between information gathered through semi-structured interviews, document analysis and participant observation, to address the following questions:

1. What is the significance of pine mushrooms to Líl̓wat people?
2. How are/were pine mushrooms managed by Líl̓wat people?
3. What is needed to safeguard Líl̓wat interests in pine mushrooms?

I describe pine mushroom ethnomycological practices used by Líl̓wat people, as well as how these practices fit into a larger social project of revitalizing cultural identity, and resisting ongoing colonial institutions. I conclude that an ecocultural valuation of forest resources is necessary for forest management to respect Indigenous rights.

I fulfill goal 4 throughout my research by observing the S7ístken Líl̓wat Research Protocol (Leo et al., 2006), including setting research objectives according to community-defined needs, and engaging in authentic research and non-research relationships with Líl̓wat people. I further describe my experience working as a non-Indigenous researcher working with an Indigenous community, in 1.7. Statement of Positionality, below.

1.2. Pine Mushrooms

The pine mushroom is the focal species of my research by request of the Líl̓wat Nation. Rare due to specific habitat needs and variability in fruiting, along with highly coveted status in Japan, makes pine mushrooms are one of the most lucrative wild mushroom species in the world. British Columbia is a major exporter of pine mushrooms (Tedder, 2008), with one of the most productive areas located within Líl̓wat traditional territory (Wiensczyk & Berch, 2001). Líl̓wat community members have raised concerns over the future availability of pine mushrooms for local use, for both subsistence and income-generating purposes (J.Gabriel and K.Tindall, personal communication, January 25, 2019). Logging in pine mushroom harvesting areas and harvesting by non-Líl̓wat mushroom pickers are cited as the primary activities of concern (Ibid). With no regulations on harvest or access (Hamilton, 2012; Mitchell, Tedder, Brigham, Cocksedge, & Hobby, 2010; Tedder, 2008), indiscriminate harvesting practices are common, including overharvest and disturbing the forest floor (Kaesuk Yoon, 1992; Mitchell et al., 2010) to expose the youngest and most valuable mushroom fruiting stage— the “button”. In addition to being intensively harvested for commercial sale, the productivity of pine mushroom habitat is put at risk by logging (Berch & Kranabetter, 2010) of commercially important timber species required by pine mushrooms to form an ectomycorrhizal relationship.

Pseudotsuga menziesii (Douglas-fir), is one of three tree species commonly found in the dominant canopy layer where pine mushroom habitat has been studied in British Columbia (Berch & Wiensczyk, 2001). Other species often found in the dominant canopy layer include *Tsuga heterophylla* (western hemlock), and *Pinus contorta* (lodgepole pine) (Berch & Wiensczyk, 2001). Although sometimes found in recently logged areas, it is generally held that later seral stage forest is needed to support fruit bodies (Trowbridge & Macadam, 1996, in Gamiet et al., 1998; J M Kranabetter, Friesen, Gamiet, & Kroeger, 2005), as is poor-to-medium rich soil (Ehlers, Fredrickson, & Berch, 2007; Gamiet et al., 1998; J M Kranabetter et al., 2005). Sub-mesic soil moisture is required to support commercially desirable levels of pine mushroom productivity.

Pine mushrooms are also inherently variable (Luoma et al., 2006) and elusive as fruiting bodies are often hidden from view by forest litter or may be present belowground (Yang, Skidmore, Melick, Zhou, & Xu, 2006), making it difficult to obtain occurrence data for habitat modeling. Líl̓wat IK, held in memory by many community members, contains detailed and temporally extensive ecological records, including the occurrence of pine mushrooms in Líl̓wat territory.

Beyond filling gaps in occurrence data, Líl̓wat IK can help to elucidate the dynamic interactions between pine mushrooms and the larger, place-based, ecocultural system of which they are a part.

1.3. Líl̓wat People

There is an inextricable link between Líl̓wat people and non-human beings with their territory that informs the way that Líl̓wat people relate to and care for their territory. For example, according to the oral history, *The Haito'laux and Wolf People, Ancestors of the Liluet'o'l* and *The S'ä'innux* Líl̓wat people are primarily descended from a union between the Xet'ulacw of Lillooet Lake, and the Wolf people of Birkenhead River (formerly Pole River), with some descended from the S'ä'innux (Teit, 1912). Ancestors that did not accept the union to become venison-eating humans, kept their original form (the Xet'ulacw) or were transformed into wolves (the Wolf people), while the S'ä'innux continued to maintain a half-human half-fish form (Ibid). The Transformers, magical beings said to have traveled from the mouth of the Fraser River, are responsible for delineating the boundaries between Líl̓wat territory and nearby St̓át̓yemc territory to the east, as well as for imparting lessons on how to live in relation to other humans and non-human beings (Teit, 1912). Many of these lessons are documented and traditionally transmitted through sqweqwel' (true stories) and sptakwlh (legends)--collectively referred to as Líl̓wat oral history (Líl̓wat Nation, 2010b). While relationships with the land are an important part of Líl̓wat culture and identity, the annexation of Líl̓wat territory and the infringement of Líl̓wat rights by, first, British, and later, Canadian governments, have significantly disrupted Líl̓wat ways of life. Thus, a necessary precursor to the topics of my thesis is to reflect on Líl̓wat-settler relations and resistance to colonialism as the larger context for my research. It is because of this history that there is a need to make arguments in support of Líl̓wat claims to their resources and the strength of Líl̓wat knowledge.

1.4. Líl̓wat-Settler Relations

Líl̓wat Territory, like all Indigenous land in British Columbia, has a long history of land and resource speculation and exploitation by settlers, fueled by colonial dreams of wealth at the expense of Indigenous peoples. Beginning with the Fraser River Gold Rush in 1858, the Cariboo Gold Rush in 1862, and the timber and agricultural land speculation that followed,

Líl̓wat territory has been transformed physically and ideologically by settler laws, policies, institutions and practices. These “discursive technologies”, authorized professionals, government officials, corporations, and other non-Indigenous entities to “abstract ‘the forest’ from its cultural ‘surrounds’ ” (Willems-Braun, 1997, p. 6). Part of the de-culturing of the forest was achieved by segregating Líl̓wat and other Indigenous peoples on reserves. Confinement on reserves prevented Líl̓wat from accessing their Territory, practicing their traditional land uses and undermining their ability to keep customs alive. Coupled with cultural assimilation initiatives, the colonial government worked to eliminate the traditional beliefs that underpin Líl̓wat rules governing use of land and resources, and superimposed its own form of property rights and the accompanying systems that empower their existence (Nemoto, 1998). The intent could not be more explicit that this statement by then-Prime Minister John A. Macdonald, published in the Sessional Papers of Parliament (Canada, 1887):

The great aim of our legislation has been to do away with the tribal system and assimilate the Indian people in all respects with the other inhabitants of the Dominion as speedily as they are fit to change. (p. 37)

One of the earliest laws that sought to erase Líl̓wat and more generally, Indigenous presence, across British Columbia, was the Proclamation of 1859 by James Douglas, then-Governor of British Columbia. The Proclamation states that “All the lands in British Columbia, and all the Mines and Minerals therein, belong to the Crown in fee” (Government of British Columbia, 1859). Shortly thereafter a suite of other laws were passed that systematically denied Indigenous rights, in spite of the 1763 Royal Proclamation that both recognized Aboriginal title and forbade the granting of lands that were not ceded to or purchased by the Crown. Examples include:

- The *British North America Act* (1867) assigned control over land to provinces, which British Columbia became when it entered the confederation of Canada in 1871.
- The Gradual Enfranchisement Act (1869) imposed a new governance system, including who should be Chief, how their position should be determined, and how long they should hold this position.
- The *Indian Act* (1880) defined who is/not considered an “Indian”, and asserted that legal title over reserve land and all the resources therein, belongs to the Crown. When amended in 1884, the Act prohibited potlatches and winter dance ceremonies, which

Moss and Gardner-O'Toole (1991) noted were important customary practices for upholding social order and property rights.

By 1933, the settler population in Pemberton Meadows was almost twice that of the Líl̓wat, and was accompanied by 2,000 cattle and eight sawmills (Nemoto, 1998). The Líl̓wat population had previously been decimated by small pox in the early years of European arrival, *resulting in tens of thousands of people…buried throughout [the] whole area of land which surrounds the Lillooet Lake* (Ishmeshkeya* 1991, as cited in Crompton, 2006, p. 33).

The Líl̓wat community suffered more losses as the Canadian Department of Indian Affairs enforced compulsory attendance at residential schools, where an untold number of Indigenous children suffered severe and multiple forms of abuse and many of whom did not survive (Truth and Reconciliation Commission of Canada, n.d.). Prohibitions on discussions of Indian land claims (1927-1951), and denial of Indigenous people's right to vote until 1960 further suppressed Líl̓wat agency. At the same time, the Government of Canada imposed its paternalistic presence on Líl̓wat community governance and daily life, exemplified by the fact that a Department of Indian Affairs (DIA) representative not only lived in the community, but also effectively controlled the band council until 1966 (Nemoto, 1998).

1.5. Líl̓wat Resistance

Egregious a history as it is, it is imperative not to conclude that "Indigenous Nations have acquiesced to the imposition of Canadian sovereignty" (Crompton, 2006, p. 12). It is the contrary. Líl̓wat people have long resisted oppressive measures by settler governments. In 1873, Líl̓wat Nation was among the Lillooet Tribe members to petition for their rights. In the Lillooet Declaration of 1911, Líl̓wat and other signatories declared their position as the rightful owners of their territories, discounted Crown claims to their land, and documented the violation of their rights by British Columbia. It would be decades before the next major act of resistance took place in Líl̓wat territory, presumably due to the debilitating effects of residential schools and the "Sixties Scoop[3]" on individual and community wellbeing. Interviewee 3 (October 21, 2019) likened the effect to being programmed. Although Líl̓wat people were no longer confined to the

[3] A period in Canadian history between the 1950's – 1980's, during which 20,000 Indigenous children were adopted out of their ancestral communities and suffered traumas comparable to those experienced by Residential School Survivors (Cardinal 2017).

boundaries of their reserve, that “form of assimilation process convinced people they weren’t allowed [on their own territory]. They were actually sneaking in a sense”-- a mindset that did not change until the 1970’s.

In 1975, Líl̓wat people protested as they learned that Elders in their community had their fishing nets seized by the federal Department of Fisheries and Oceans (DFO) (Líl̓wat Nation, 2010b; Líl̓wat Peoples Movement, 1991). Four years later, in 1979, Líl̓wat people contested logging on reserve land by Canadian Forest Products (Líl̓wat Peoples Movement, 1991). In 1982, the Provincial government granted Interfor a Forest License to harvest timber for 15 years from what Crompton (2006) noted as *the most sacred area within Líl̓wat traditional territory* (p. 31), *Mkwal’ts* (Ure Creek). In preparation for logging, the company began blasting rock (including places featuring historic Líl̓wat pictographs) and building roads through important cultural sites, in spite of Líl̓wat opposition. Líl̓wat people responded by peacefully blocking Lillooet Lake Road between 1990 and 1991. Sixty-three people were arrested and charged. Crompton (2006) describes the violence inflicted by Royal Canadian Mounted Police (RCMP) officers in detail, which resulted in arrestees being rendered unconscious, some with broken bones and others suffering permanent nerve damage. While gruesome, the 1990-91 roadblock and preceding events demonstrate the persistence of Líl̓wat resilience in the face of Canadian colonialism. These events, as attested by Interviewee 3 (October 21, 2019), were also a catalyst for many Líl̓wat people in realizing their rights: “Rebels, road blocks. People started to figure out their own identity”.

In 1992, Líl̓wat Nation opted not to participate in modern treaty[4] negotiations— a process wherein the terms of engagement are effectively controlled by the Canadian government. Líl̓wat Nation chose instead to pursue independent avenues to assert their rights and pursue self-determination. Among these include:

- 2003: Using the federal court system to claim Líl̓wat aboriginal title and rights and seek damages for lands taken by British Columbia and Canada (Crompton, 2006)
- 2005: Signing the first of subsequent Forest Agreements with the Province of British Columbia, gaining access to an independent revenue stream through forest tenure (T.

[4] An agreement between First Nations, and the Governments of Canada and British Columbia, that acknowledges and outlines rights and obligations between parties on a “government to government basis” (BC Treaty Commission, 2021).

Smith & Bulkan, 2021)

- 2006: Asserting a Líl̓wat defined vision for land use in its territory, governed by Líl̓wat values and customary stewardship, the Líl̓wat Land Use Plan (LLUP) (2006). The LLUP states that *[it] takes precedence over others' plans, because of our prior presence here and because of the strength of our claim of uninterrupted use of our Traditional Territory*" (Líl̓wat Nation, 2006, p. 83)
- 2006: Founding Líl̓wat Forestry Ventures (LFV) to enable "in-house" forest management, providing Líl̓wat-led training and employment, generating revenue through timber sales and subcontracting forestry and firefighting services, increasing oversight of on-the-ground forestry activities, and enabling access to more tenure. As of 2018, LFV held 20% of timber cutting rights by volume in their territory (T. Smith & Bulkan, 2021).

1.6. Mapping as Resistance

Mapping is another tool Líl̓wat Nation is using to resist historic and ongoing colonial forces and assert their rights to their land and culture. In 1990, Líl̓wat Nation was refused an injunction against Interfor to halt the road-building destroying Líl̓wat pictographs (Crompton, 2006), believed by community members to be due to an absence of evidence proving the existence of the pictographs before they were destroyed (Jones, in Atkinson, 2012). Líl̓wat Nation has since developed an extensive spatial inventory of cultural sites, which has been used in negotiations over proposed recreation, logging, mining and hydropower activities, as well as informing the Líl̓wat Land Use Plan (Atkinson, 2012; Líl̓wat Nation, 2006). Thus mapping pine mushroom habitat is a continuation of Líl̓wat Nation's ongoing "counter mapping" (Peluso, 1995) efforts. Peluso (1995) argues that state mapping, of forests in particular, enables state control over resources by excluding or making invisible whomever might stand in the way of resource development. "Counter mapping" provides a means for traditional management claims to be formalized, contesting claims by the state (Ibid).

Mapping pine mushroom habitat based on traditional and contemporary Líl̓wat knowledge and use enables Líl̓wat Nation to further document uninterrupted Líl̓wat presence in their territory, and make visible pine mushrooms as an important cultural value to be accommodated in forest management. On its own, a map of pine mushroom habitat is an incomplete representation of the territory's importance to Líl̓wat people. As an additive feature to a larger dataset, however, a spatial layer of pine mushroom habitat makes more explicit that there is no place in Líl̓wat

territory that is without use or significance. While not all Líl̓wat people rely on pine mushrooms for subsistence, or hold Indigenous knowledge of where they grow and how they should be managed, mapping pine mushroom habitat creates a placeholder for those lands to remain available as places for Líl̓wat people to choose to live and learn as their ancestors have done since “time out of mind”.

1.7. Statement of Positionality

As a non-Indigenous researcher working with an Indigenous community, I acknowledge that who I am as a person has a direct impact on my access to and interpretation of, the information and experiences I encounter during my research. I am, and I am not, white. Reflecting on “whiteness” is relevant, as whiteness is not just skin colour; it is 'a location of structural advantage, a standpoint from which those of us who are white understand the world and our position in it and a set of cultural practices that in white settler societies...are dominant' (Aveling, 2013, p. 208). Ethnically speaking, I am Chinese and Caucasian, and was raised in a suburban city in Ontario, Canada with little to no exposure to my Chinese ancestry. The income earned by my family throughout my childhood positioned our household below the Statistics Canada-defined poverty line. We often relied upon foodbank and other charitable services, and resided in government-subsidized housing. The neighbourhood in which I was raised regularly experienced domestic and substance abuse-related violence, while also culturally rich relative to surrounding communities, as many of my neighbours were recently immigrated families. My mother was university-educated, and trilingual, and my maternal grandparents were raised by families who owned land and businesses in Halifax, Canada. I was educated in a French-immersion public school, and graduated high school with honours. I hold a Bachelor of Science degree, as well as professional designations that allow me to access job positions with higher income-earning potential. Thus, while my experiences linked to childhood poverty, and my status as a visible minority have presented disadvantages, higher levels of education and wealth held by previous generations in my family have afforded me privileges at this stage of my life that are more closely associated with white settler society. I have access to funding to support my research and my livelihood, to professors and other university-funded infrastructure, and to paid-access only scholarly literature. I am comfortably-housed, have access to healthy and preferred foods, have many options for modes of transportation, as well as access to a diverse range of extended healthcare services. Collectively these privileges both bring me closer to, and farther away from, effectively conducting my research.

As a result of my childhood experiences, along with the time I have spent working and developing friendships with Líl̓wat community members, I am able to empathize with some of the injustices experienced by Líl̓wat people. As a non-Indigenous person, however, I can never fully comprehend the impact of the racist and colonial traumas inflicted upon Líl̓wat people. In order to engage ethically as a researcher, in spite of limitations to my understanding of Líl̓wat experiences, I draw from Indigenous research methodologies, which emphasize reciprocity and relationality with both people and place (Denzin & Lincoln, 2008). More specifically, I am guided by the Líl̓wat S7ístken Research Protocol (Leo et al., 2006), which outlines how research can be undertaken according to, and in respect of, Líl̓wat values.

Chapter 2: Incorporating Indigenous knowledge to model pine mushroom (*Tricholoma murrillianum*) habitat

2.1. Introduction

The long temporal record of detailed ecological information held within Indigenous knowledge (IK) [5] is increasingly attracting interest from scientists seeking to integrate data from Western science and IK. Studies in which IK is being applied range from broad scale issues, such as climate change adaptation (Petzold, Andrews, Ford, Hedemann, & Postigo, 2020), to species-specific, localized case studies (Alexander et al., 2019). IK is less frequently utilized within species distribution modeling (SDM) studies (Skroblin et al., 2019). When IK is incorporated, however, studies largely concern wildlife and plant distributions (Bélisle, Asselin, Leblanc, & Gauthier, 2018). Using SDM to explicitly predict fungal species occurrence is an emerging subfield of SDM research (Hao, Guillera-Arroita, May, Lahoz-Monfort, & Elith, 2020), however, few, if any, examples incorporate IK.

[5] I use the term “Indigenous knowledge” in this study to distinguish the “cumulative body of knowledge, practice, and belief” (Berkes, Colding, & Folke, 2000, p. 1252) held and transmitted as part of an Indigenous culture, from other local knowledge of pine mushrooms held and transmitted by non-Indigenous peoples.

While IK can enhance SDM studies, there are challenges to incorporating IK into the modeling process. Data held within IK may be difficult to transform for use within a mathematical model (Mackinson, 2001), or may be tacit, and not readily articulated (Bélisle et al., 2018; N. Turner, Deur, & Lepofsky, 2013). Data elicited from IK may also be considered biased within a scientific context (Bélisle et al., 2018; Benner, Knudby, Nielsen, Krawchuk, & Lertzman, 2019), requiring ecologists to utilize approaches from other disciplines to confer data reliability. For example, similar to power calculations used by natural science researchers to determine adequate sample size, the concept of “information power” was proposed by qualitative health researchers (Malterud, Siersma, & Guassora, 2016). Adequate information power can be achieved with a small sample provided that 1) the knowledge being elicited is held by a specific group of people, 2) participants represent the range of experiences or characteristics within the target group, and 3) methods that enable high quality dialogue and in-depth analysis are used (Ibid). Small sample sizes are not unusual when working with IK, as the knowledge may be highly specialized or held by a small group of people according to cultural protocols, or fragmented within communities whose traditional forms of knowledge transmission have been disrupted.

This potential for bias increases where only presence data is available (Fithian, Elith, Hastie, & Keith, 2015), a common challenge associated with studies of rare species, for which data may be limited or clustered (Norris, 2014). Maxent, a SDM software commonly used in conservation studies, is designed to accommodate presence-only data (S. J. Phillips et al., 2006). Key to this functionality, is the generation of pseudo-absence points against which occurrence points and environmental variable data are compared. Pseudo-absence points are randomly sampled from background locations and in doing so capture the range of the environmental conditions within the study area (Phillips et al 2009). However, if, unlike the pseudo-absence points, occurrence points are not randomly sampled and are spatially biased, model predictions may reflect the sampling effort instead of habitat suitability (Merow, Smith, & Silander, 2013). Sampling bias is not restricted to studies incorporating IK, however, and can result from modeling datasets sourced from museum records, or opportunistic sampling (Fourcade, Engler, Rödder, & Secondi, 2014). As a result, several methods have been developed to correct sampling bias when modeling species distributions in Maxent (Ibid).

For many Indigenous peoples (IP), the findings generated by ecological modeling studies can have a direct impact on their subsistence and livelihoods. There are few examples in which IK is directly involved in establishing research objectives, however, and the most common function of IK in modeling studies is simply via data collection (Bélisle et al., 2018). The former ascribes greater agency to IPs, and may prevent power imbalances that can arise between scientists and the IPs with whom they are collaborating—a concern gaining recognition amongst scholars in environmental monitoring (K. L. Thompson, Lantz, & Ban, 2020), and mapping (Barber & Jackson, 2015). Even the words “research” and “science” can call to mind negative connotations for many Indigenous peoples (Fernandez-Gimenez, Huntington, & Frost, 2006; Leo et al., 2006). The historical relationship between science and Indigenous peoples may seem out of scope to ecologists undertaking SDM studies. For ecologists wishing to incorporate IK, however, understanding an Indigenous community’s experience with unethical research is an important step towards earning trust and building a reciprocal research relationship. While establishing trust to enable collaborative research with Indigenous communities may take time, meaningful scientific outcomes can be realized. Collaborating with scientists to gather, and perhaps more importantly, own, scientific data is increasingly part of a larger effort to document and assert Indigenous rights and title (Baumflek, DeGloria, & Kassam, 2015; MacKenzie, Siabato, Reitsma, & Claramunt, 2017; Velasquez, 2014). Spatial data, in particular, are powerful tools for Indigenous communities engaged in conflicts over competing land uses, or access to species with great commercial and cultural value.

The ectomycorrhizal fungus *Tricholoma murrillianum*, a pine mushroom species, holds both cultural and economic importance to the Líl̓wat Nation (see Chapter 3), whose traditional territory is situated approximately 150 kilometers northeast of the City of Vancouver, British Columbia, Canada. The mushroom is also highly sought after by commercial mushroom harvesters as well as local peoples in British Columbia, and whose productivity is put at risk by logging (Berch & Kranabetter, 2010). British Columbia is a major exporter of pine mushrooms to Japan (Tedder, 2008), with one of the most productive areas located within Líl̓wat traditional territory (Wiensczyk & Berch, 2001).

Previous studies of *T. murrillianum* (formerly, *T. magnivelare)* largely focused on identifying habitat characteristics (Berch & Wiensczyk, 2001; Ehlers et al., 2007; Fogarty, 1998; Gamiet et

al., 1998; J. Marty Kranabetter, Trowbridge, Macadam, McLennan, & Friesen, 2002; Luoma et al., 2006) and strategies for co-management with timber (Amaranthus, Pilz, Moore, Abbott, & Luoma, 2000; Berch & Kranabetter, 2010; Bravi & Chapman, 2009). Few studies have involved mapping pine mushroom habitat (Bravi & Chapman, 2006; Trowbridge, 2005). No studies are known to have integrated IK in mapping the distribution of pine mushroom habitat in British Columbia. I do so, here, in response to a commission by Líl̓wat Nation in 2019 to map pine mushroom habitat in their territory.

In this chapter I compare two methods for incorporating IK in SDM: 1) where IK is used to locate and record pine mushroom occurrences in the field, and 2) where IK is used in place of field data to approximate and locate occurrences on a map. I thus created two modeling scenarios-- "Field" and "Verbal"-- which I used to map pine mushroom habitat across the Líl̓wat territory. In addition to examining the use of IK to generate occurrence records, I tested the predictive power of environmental variables that previous studies have associated with pine mushroom habitat. I hypothesized that the "Field" model would produce more accurate predictions than the "Verbal" model, given the relative precision of the "Field" occurrence records. I expected that site series, a fine scale ecological classification scheme that encapsulates multiple biophysical characteristics (Meidinger & Pojar, 1991) would be the most important predictor variable for both models. In addition to reviewing model results and performance, I provide insights for other ecologists wishing to work with IK and Indigenous communities in modeling species distributions.

2.2. Pine Mushroom Autecology

2.2.1. Species

Tricholoma murrillianum Singer is one of three ectomycorrhizal species of pine mushroom native to North America (Trudell, Xu, Saar, Justo, & Cifuentes, 2017). Previously known as *Tricholoma magnivelare* (Peck) Redhead, recent DNA analysis has shown that eastern and western varieties are, in fact, separate species (Trudell et al., 2017). Long before either scientific name was assigned, however, the Líl̓wat people knew the pine mushroom as sq̓em̓s--

the "edible mushroo[m] that grows under or near fir trees (Joseph et al., 2013). Through the remainder of this chapter I refer to the species using its common name: pine mushroom.

2.2.2. Ectomycorrhizal Relationship

As the Ucwalmícwts (Líl̓wat) name for pine mushroom indicates, *Pseudotsuga menziesii* (Douglas-fir), is a common host for this ectomycorrhizal species, and is one of three tree species commonly found in the dominant canopy layer where pine mushroom habitat has been studied in British Columbia (Berch & Wiensczyk, 2001). Other species often found in the dominant canopy layer include *Tsuga heterophylla* (western hemlock), and *Pinus contorta* (lodgepole pine) (Berch & Wiensczyk, 2001). Some Líl̓wat mushroom pickers assert that *Thuja plicata* (western redcedar) is more commonly present in pine mushroom habitat than western hemlock, however it is unclear whether these observations concern overstorey trees, or understory canopy layers.

The age of tree host required for *Tricholoma murrillianum* to produce sporocarps, or fruit bodies, is not universally agreed upon. In the broader Pacific Northwest, the typical stand age for pine mushroom habitat is considered to be 100-200 years, however with reports from mushroom pickers having found pine mushrooms in stands as young as 50 years (de Geus, 1995). There appears to be consensus, however, that a later seral stage forest is needed to support fruit bodies (Gamiet et al., 1998; Hosford, Pilz, Amaranthus, & Molina, 1997; J M Kranabetter et al., 2005).

2.2.3. Suitable Habitat

While pine mushrooms are found in several ecosystem types in British Columbia (Table 2.1), all of which feature dry summers, and moist, cool winters (Green & Klinka, 1994) common characteristics include subxeric to submesic soil moisture regimes, and poor to medium soil nutrient regimes (Ehlers et al., 2007; Gamiet et al., 1998; J M Kranabetter et al., 2005). In order to support pine mushroom abundance at commercial harvest levels, however, forests containing sub-mesic soils are required (Berch & Wiensczyk, 2001).

Table 2.1. Ecosystems where productive pine mushroom habitat has been found in the study area (grey), and across British Columbia (white) (Berch & Wiensczyk, 2001). Ecosystem classifications are given at two regional scales: bigogeoclimatic zone and subzone (Meidinger & Pojar, 1991)

Zone	**Subzone**
Interior Douglas-fir (IDF)	Interior Douglas Fir Wet Warm (IDFww)
Coastal Western Hemlock (CWH)	Southern Moist Submaritime Coastal Western Hemlock (CWHms1)
	Southern Dry Submaritime Coastal Western Hemlock (CWHds1)
Zone	**Subzone**
Interior Cedar-Hemlock (ICH)	Moist Cold, Hazelton variant Interior Cedar-Hemlock ICHmc2
	Moist Warm, Columbia-Shuswap variant Interior Cedar-Hemlock (ICHmw2)
Sub-Boreal Pine-Spruce (SBPS)	Very Dry Cold Sub-Boreal Pine-Spruce (SBPSxc)
Engelmann Spruce-Subalpine Fir (ESSF)	Engelmann Spruce-Subalpine Fir Very Dry Very Cold, West Chilcotin variant (ESSFxv1)

At a coarse spatial scale, all of the above-listed ecosystems and soil conditions present suitable habitat for pine mushrooms. Fine scale spatial and temporal variations in environmental conditions can strongly influence the development of shiros and sporocarps, however. These conditions are not well documented in the scientific literature, but are effectively tracked by Líl̓wat mushroom pickers as Indigenous knowledge. For example, creek beds and gullies are reported more likely to yield sporocarps in dry years, while the combination of a dry summer and early snowfall can lead to no, or very poor, fruiting-- as was the case in 2019 (J. Gabriel,

personal communication, October 3, 2019). A Líl̓wat elder reports that the presence of thick, white fog can indicate where and when pine mushrooms are present. Gamiet et al. (1998) reported similar findings: that although shiro development requires warm and dry conditions, fruiting requires cool and moist conditions. The question of suitable habitat is therefore best addressed by analysing ecosystem composition, structure and function at multiple scales.

2.3. Methods

2.3.1. Study Area

Líl̓wat Nation Traditional Territory is a 797,131 hectare area that "extends south to Rubble Creek, north to Gates Lake, East to the Upper Stein Valley, and west to the coastal inlets of the Pacific Ocean" (Líl̓wat Nation, 2010b), in British Columbia, Canada. Nearby urban centers are the Village of Pemberton, and the Resort Municipality of Whistler. The extent of my study area within Líl̓wat Territory matches that of the Terrestrial Ecosystem Mapping (TEM) dataset (Data BC) (Figure 2.1), which is the most spatially limited dataset amongst those I modeled (Table 2.2). The total study area is 408, 675 hectares, which is approximately 52% of Líl̓wat territory.

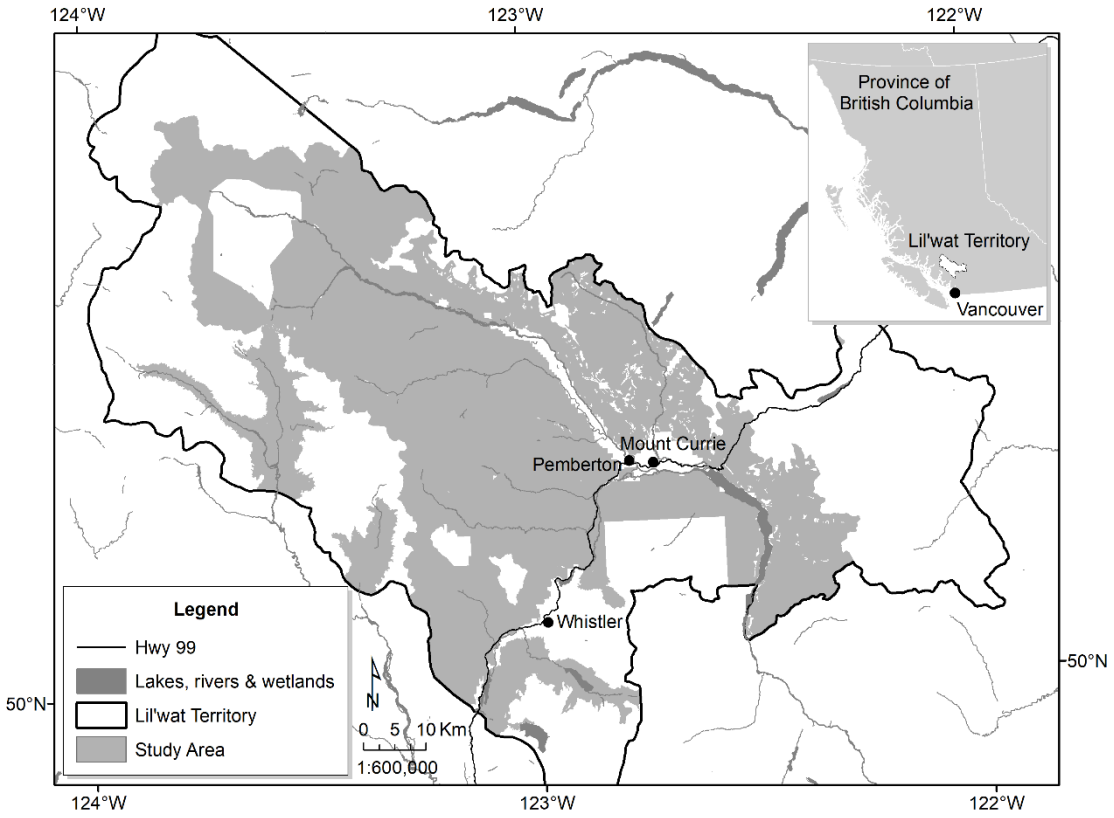


Figure 2.1. Study area, which includes all of the Lílwat Nation traditional territory in southwestern British Columbia (inset map) that is covered by available spatial data (in light grey) required for modeling.

2.3.2. Overview of Methods

I developed two subsets of occurrence records as inputs to the habitat suitability models: a field-based dataset and a verbal dataset. Both datasets are presence only, because fruiting bodies are often hidden from view by forest litter or are present belowground, thus leading to inaccurate absence records (Yang et al., 2006). Pine mushrooms are also inherently variable (Luoma et al., 2006), and absence during the sampling period may be due to recent weather conditions and not habitat unsuitability. Each set of presence-only occurrence records was run as its own model scenario ("Field" and "Verbal") using the species distribution modeling software Maxent (S. J. Phillips et al., 2006). Each model was tested with the same environmental variables to

determine which variable(s) best predict pine mushroom habitat. Each step is described in detail, below.

2.3.3. Field-based occurrence data

I used the Terrestrial Ecosystem Mapping (TEM) spatial dataset (Data BC) to map ecosystems identified by other studies as suitable pine mushroom habitat within Líl̓wat territory. In addition to this preliminary mapping, I consulted experienced Líl̓wat mushroom pickers to determine where pine mushrooms would most likely be found in Líl̓wat territory. Both sets of information were used to identify potential sampling locations across the territory.

Occurrence data were collected over 12 days, organized into four sampling periods that varied between one and four days in length, and were conducted between September 23, 2019 and November 27, 2019 to correspond with the pine mushroom fruiting period in this region. Collection took place during daylight hours to maximize visibility. Each sampling location was traversed and visually surveyed by a team of two to three people, walking between five and ten meters apart until one or more mushrooms were observed. In cases where more than one mushroom (i.e. a cluster) was observed, any mushroom within the “neighborhood” (Smith et al 2004) of a one-meter quadrat was considered part of the same cluster and only one occurrence data point was recorded (Figure 2.2). Each neighborhood was expanded until no further adjacent one-meter units contained mushrooms. For every occurrence, I recorded geographic coordinates using an iPad mini 4 with built-in GPS, in Avenza Maps 3.11 at a minimum horizontal accuracy of 32 meters, and using maps at a scale of 1:100,000. Once GPS coordinates were recorded, the surrounding area was surveyed within an approximate 50-meter radius for additional pine mushroom occurrences. New occurrences were recorded using the same method. Fifty-three occurrences were recorded in the field.

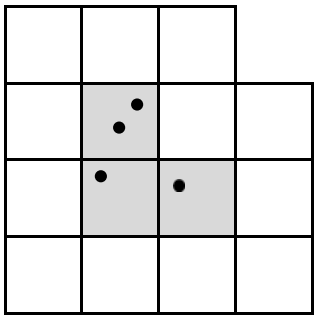


Figure 2.2. The “adaptive cluster sampling” method (D. R. Smith, Brown, & Lo, 2004) used in this study. Dots indicate pine mushrooms observed within each one-meter quadrat. Sampling boundaries extended incrementally into the surrounding “neighborhood” until no additional mushrooms were observed. The cluster of grey squares was recorded as a single occurrence data point.

2.3.4. Verbal occurrence data

I recorded the approximate locations of 57 “verbal” occurrences on a 1:100,000 scale digital map, based on the identification of current and historic pine mushroom picking areas by four experienced Líl̓wat mushroom pickers. Recording occurrences at this small scale avoided misrepresenting data precision, as sporocarp development is highly variable, and shiro size is unknown. Occurrences were recorded using the same map, iPad device and Avenza mapping software as for the field occurrence data.

Collectively, the distribution of “Field” and “Verbal” occurrence localities spans all of the major drainages within Líl̓wat territory: Lillooet River, Birkenhead River, Green River, and Lillooet Lake, capturing a wide range of representative ecological conditions within the study area.

2.3.5. Modeling

To model habitat suitability, I used the species distribution modeling software Maxent (S. J. Phillips et al., 2006). Maxent is robust to presence-only data and small datasets, which are prone to overfitting, but common when modeling elusive species such as pine mushrooms. The

results of the Maxent models are predictions that indicate the probability of suitable habitat, not the probability that the species itself will be present (S. J. Phillips et al., 2006).

2.3.5.1. Model Predictors

I selected five ecological variables to test as predictors for both model scenarios: a) site series, b) leading tree species (dominant tree by volume), c) age of leading tree species, d) tree canopy cover, and e) elevation (Table 2.2).

Table 2.2. Data sources for model variables

Variable	Type	Data	Source
site series	categorical	Terrestrial Ecosystem Mapping (TEM)	Data BC https://catalogue.data.gov.bc.ca/dataset/ 4e71fd99-09a0-4573-aecd-b8030b48f0b7
leading tree species	categorical	VRI - 2018 - Forest Vegetation Composite Rank 1 Layer (VRI)	Data BC https://pub.data.gov.bc.ca/datasets/ 02dba161-fdb7-48ae-a4bb-bd6ef017c36d/2018
age of leading tree species	categorical (10-year cohorts)		
canopy cover	continuous		
elevation	continuous	ASTER Global Digital Elevation Model Verion 3	NASA/METI/AIST/Japan Spacesystems, and U.S./Japan ASTER Science Team https://asterweb.jpl.nasa.gov/gdem.asp

2.3.5.2. Background Sample Selection

To correct for potential bias in my occurrence data due to using IK, I used the bias grid approach (Elith et al., 2010) to upweight background points in areas where occurrence points have fewer neighbours (Brown, 2017), thereby incurring the same bias in background sampling

as the occurrence point sampling (Elith et al., 2010; Fourcade et al., 2014; Merow et al., 2013; S. J. Phillips et al., 2009).

I used SDMtoolbox v2.4 (Brown, Bennett, & French, 2017) to, first, rarefy occurrence data and remove spatially autocorrelated occurrence points within 30-meters of each other. I chose 30 meters to match the resolution of the DEM, and also as it is a more conservative measure than the 20-meter minimum sampling distance applied by Ehlers et al (2007) in their study of pine mushroom habitat characteristics. Rarefication corrected for spatial autocorrelation by reducing the number of training points from 53 field and 57 verbal occurrences, to 42 and 55, respectively. I then input each of the rarefied occurrence point files into the Gaussian Kernel Density of Sampling Localities tool within SDMtoolbox to produce a 30-meter resolution bias grid ASCII file for each of the model scenarios, as described below.

2.3.5.3. Generating the Models

I modeled each scenario using the Run MaxEnt: Spatial Jackknifing tool in SDMtoolbox v2.4 and MaxEnt v3.4.0 (S. Phillips, 2017). The process for both models involved two main steps. Step 1 integrated model validation and calibration, where each model was first calibrated and then validated with test data produced through geographically structured k-fold cross validation. The previously-discussed spatial bias common to presence-only data was addressed in Step 1 by incorporating a bias grid, which I customized for each model scenario. Step 1 also tested different combinations of variable features (mathematical transformations of variable data), and different regularization parameters. I used the tool's default regularization multipliers 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, and 5.0. Maxent produces continuous and binary predictive outputs, but the latter requires a threshold be set as a model input. Maximizing the sum of sensitivity and specificity (max SSS) in selecting a binary threshold generates good results for distinguishing between presences and absences, and thus a more reliable binary predictive output (Liu, White, & Newell, 2013). I used max SSS as the threshold selection method for both binary model scenarios.

Step 1 produced a series of preliminary models, followed by a recommended best model based on the the lowest omission rate error, followed by highest AUC value, and then simplest feature class parameters. Features were automatically selected by the model based on the number of training samples (occurrence data points). Step 2 involved running the optimized model to generate the final outputs: continuous and binary predictive maps of pine mushroom habitat, evaluation of the importance of each environmental variable, response curves for each environmental variable, and evaluation of the model's performance.

2.4. Results

Both models generated strong predictions, as indicated by high area under the curve (AUC) values and low omission errors (Table 2.4)—statistics that report on model performance and which I discuss further below. Of greater interest, however, is the degree of similarity between model results. Both models predicted a similar total area and distribution of suitable pine mushroom habitat. Both models also found that elevation was the most important environmental variable among those tested for predicting pine mushroom habitat.

2.4.1. Predicted Suitable Habitat

The "Field" model predicted a slightly smaller total area of suitable habitat at 33,602 hectares, compared with 37,675 hectares predicted by the "Verbal" model. There is considerable overlap between the areas predicted by each model, with the majority of suitable habitat concentrated around the major river systems within Líl̓wat Territory, as well as Lillooet Lake, and within near identical elevation ranges of 200-1200 meters ("Field") and 200-1100 meters ("Verbal") (Figure 2.3, 2.4). A notable difference can be seen in the distribution of suitable habitat across the predicted elevation ranges, however. While the "Verbal" model predicted a sharp decrease in probability of presence at elevations above 700 meters, the "Field" model predicted a gradual decline (Figure 2.5).

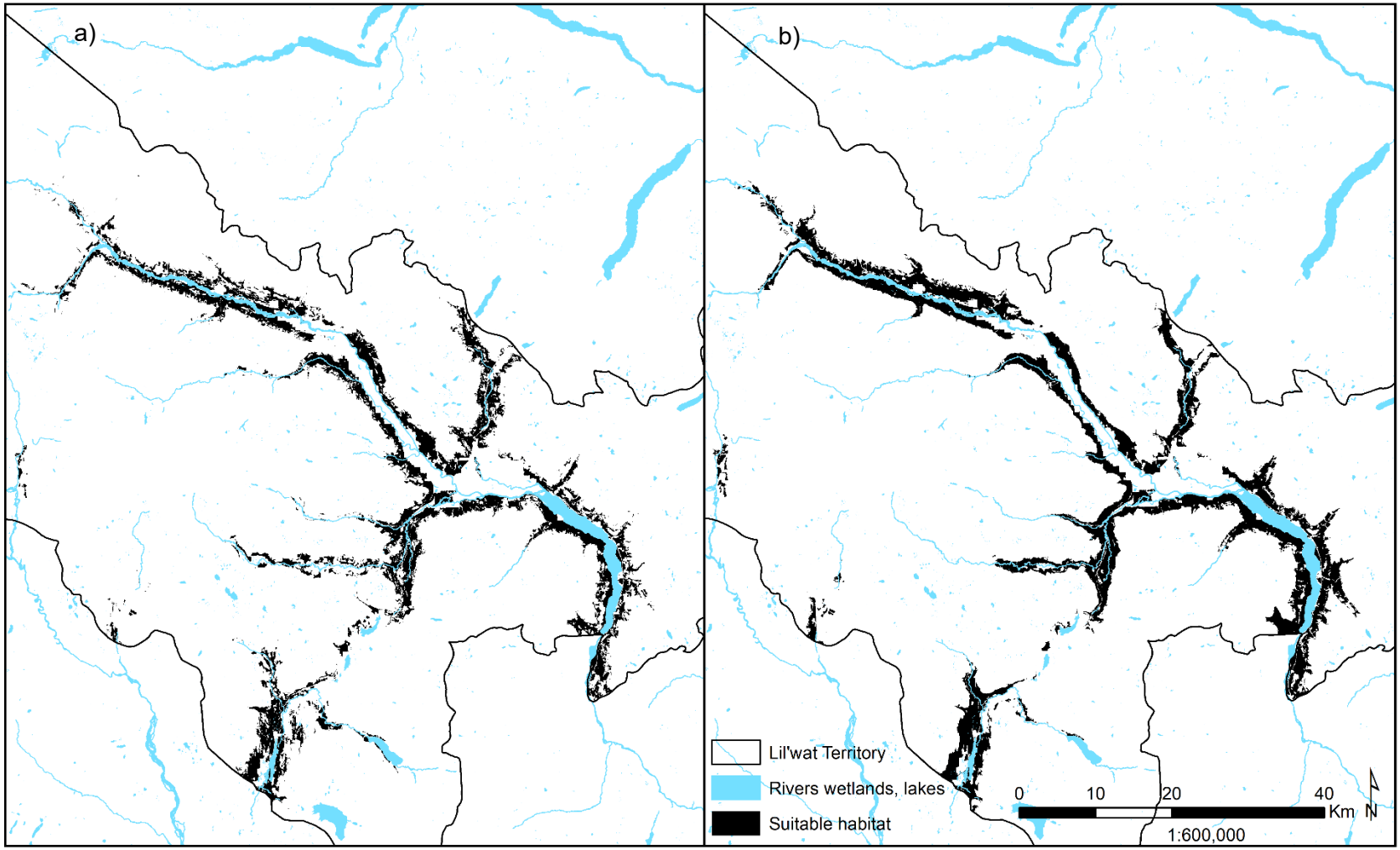


Figure 2.3. Predicted suitable habitat for Tricholoma murrillianum (pine mushroom) based on a) “Field” occurrence data, and b) “Verbal” occurrence data. Black areas indicate suitable habitat based on the threshold set by each model.

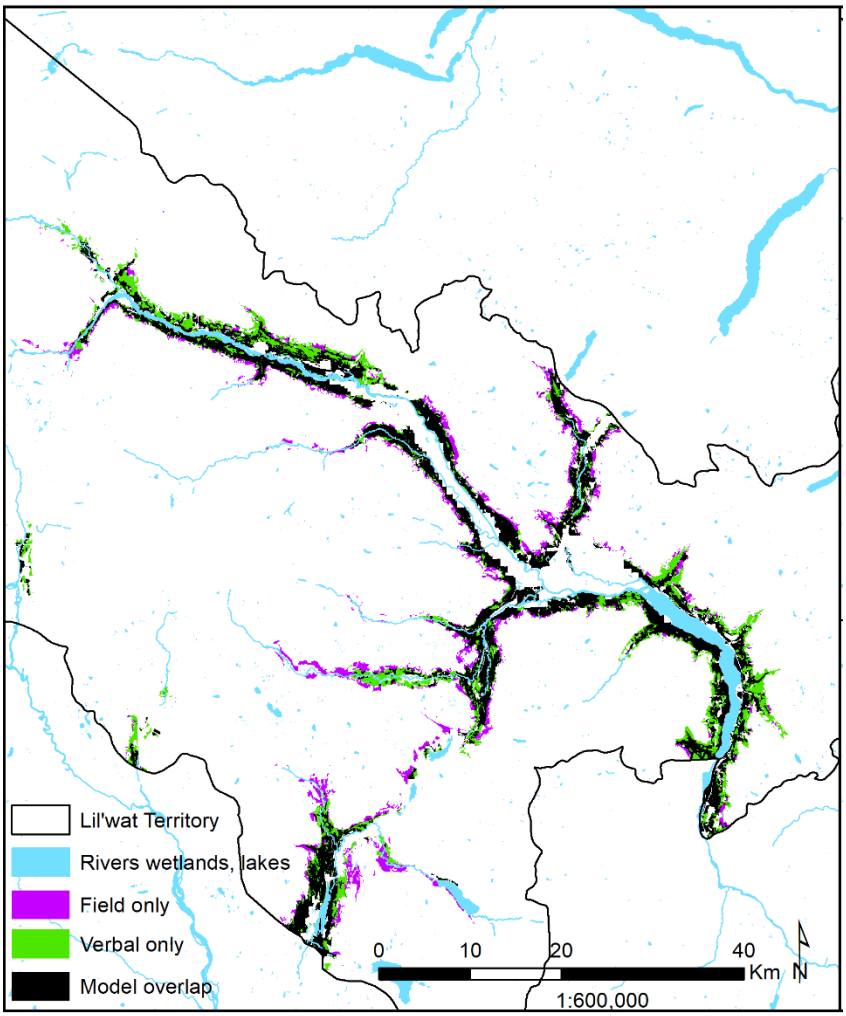


Figure 2.4. Areas of agreement (black) and disagreement (purple, green) between model predictions of Tricholoma murrillianum (pine mushroom) in the study area.

Table 2.3. Percent and absolute area predicted by the a) “Field” and b) “Verbal” models, as well as predicted as c) “Field only”, d) “Verbal only”, and e) and “Model overlap”. All values are relative to the study area (408,675 hectares).

a) Field	b) Verbal	c) Field only	d) Verbal only	e) Model Overlap
8.22%	9.22%	1.91%	2.90%	6.32%
33,067 ha	37,675 ha	7,792 ha	11,865 ha	19,657 ha

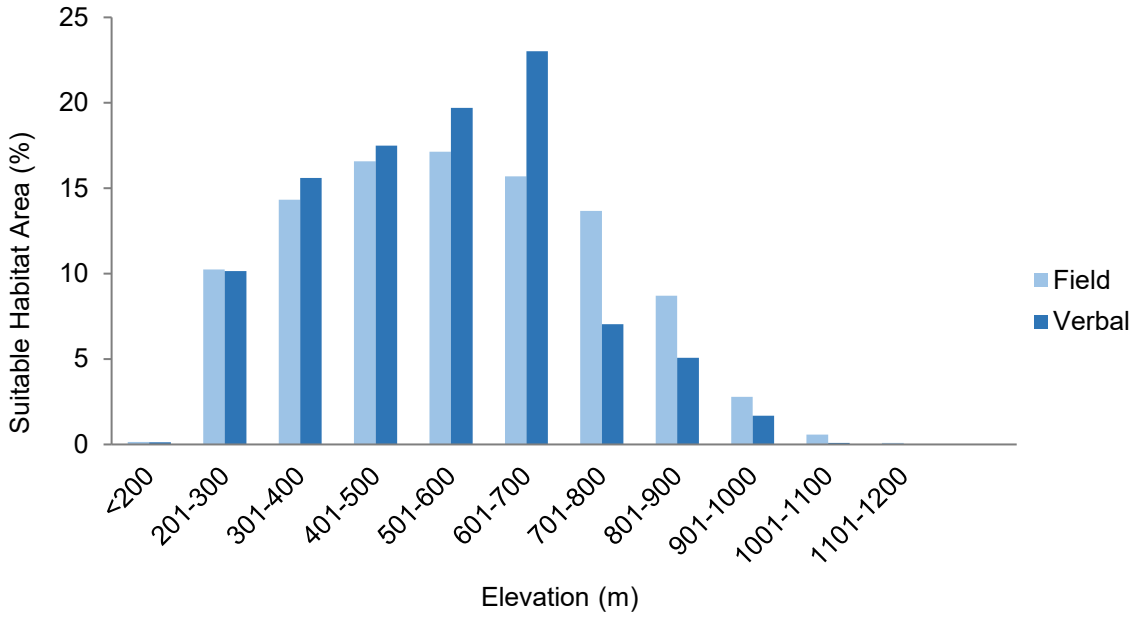


Figure 2.5. Proportion of suitable pine mushroom habitat by elevation in the study area as predicted by the Field and Verbal models.

2.4.2. Importance of Environmental Predictors

Elevation was the most influential predictor in both models, with permutation importance values of 76.7% in the “Field” scenario and 90.3% in the “Verbal” scenario (Figure 2.6). Permutation importance measures the contribution of each environmental variable to the gain of the model (S. Phillips, 2017) and thus its ability to discriminate between presence and absence localities (Merow et al., 2013).

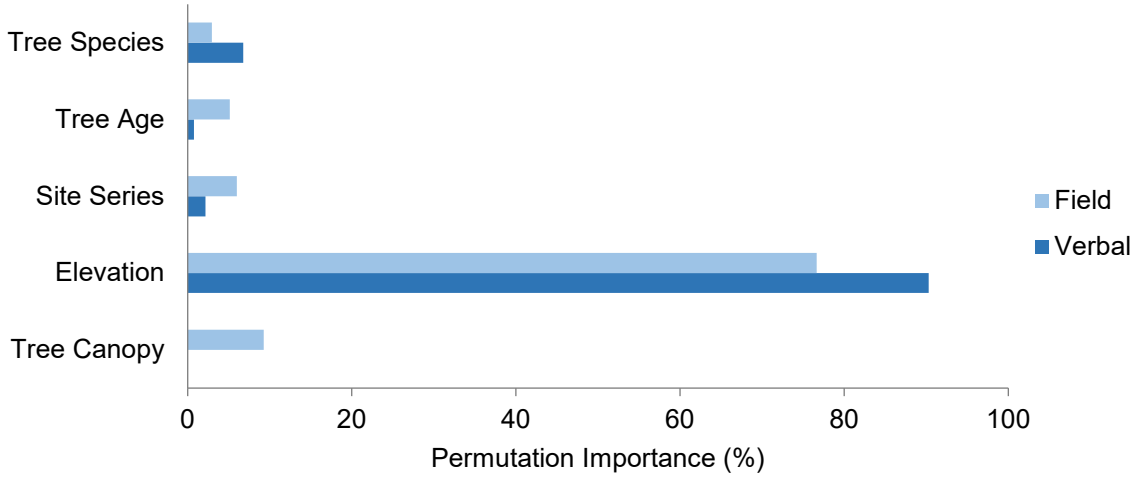


Figure 2.6. Permutation importance of environmental predictors to each model.

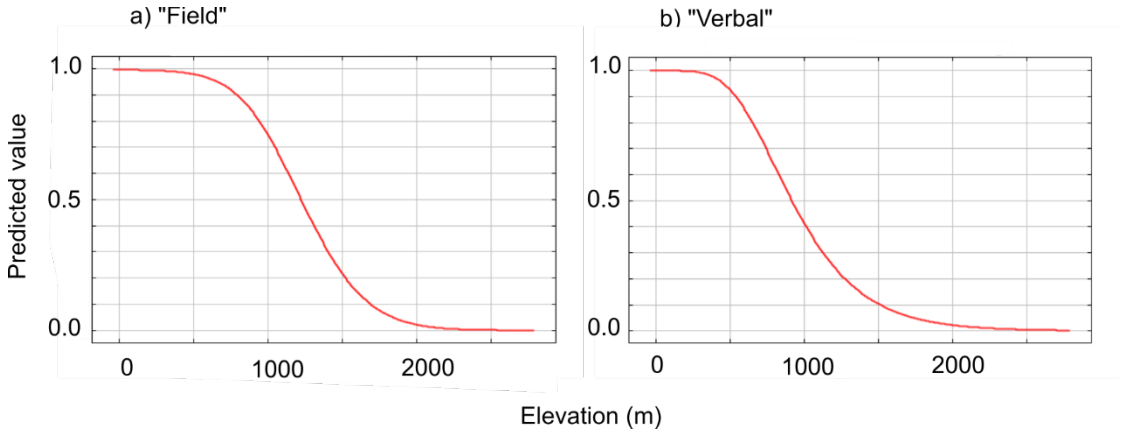
All other variables contributed less than 10% permutation importance to each model, with the least important being leading tree species at 3.0% in the “Field” model, and tree canopy cover at 0.0% in the “Verbal” model. Site series contributed only 6.0% and 2.2% permutation importance to the “Field” and “Verbal” models, respectively.

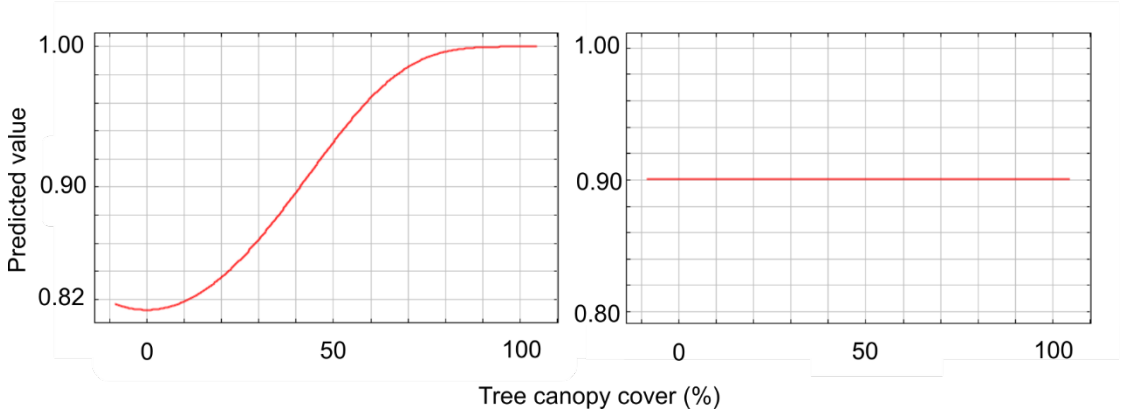
While elevation is the most important predictor variable, the probability of pine mushroom presence was correlated with most variables tested, according to each model’s response curves (Figure 2.7). For example, in the “Field” model, probability of presence increases with increasing canopy cover, although canopy has no effect in the “Verbal” model, as noted previously. The 03 (moderately dry, very poor to medium richness) site series of the CWHds1[6] subzone series is at

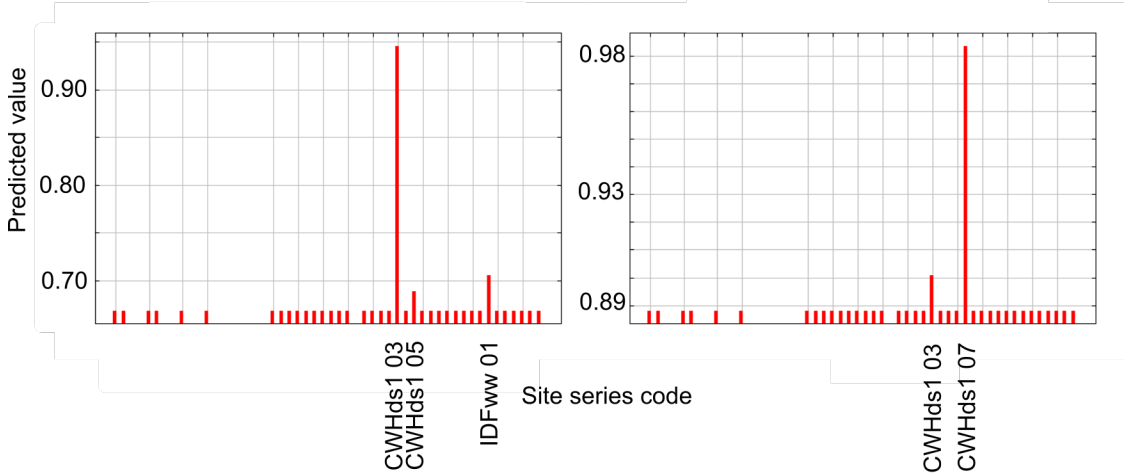
[6] Southern Dry Submaritime Coastal Western Hemlock

least 30% more likely to be associated with suitable pine mushroom habitat than other site series, according to the “Field” model. In the “Verbal” model, however, the much richer and wetter 07 site series is approximately 10% more likely than the 03 site series to be associated with pine mushroom habitat.

Douglas-fir (*Pseudotsuga menziesii*) is approximately 25% and 10% more likely to be associated with pine mushroom habitat than other tree species in the “Verbal” and “Field” models, respectively. While certain classes of older trees (90-109 years, and 140-149 years) are more likely to associated with suitable habitat, according to “Field” model results, the lack of clear pattern in the “age” response curve for either model warrants further study.


a) "Field"
b) "Verbal"
Predicted value
1.0
0.5
0.0
0
1000
2000
Elevation (m)


Predicted value
1.00
0.90
0.82
0.80
0
50
100
Tree canopy cover (%)


Predicted value
0.90
0.80
0.70
0.98
0.93
0.89
CWHds1 03
CWHds1 05
IDFww 01
Site series code
CWHds1 03
CWHds1 07

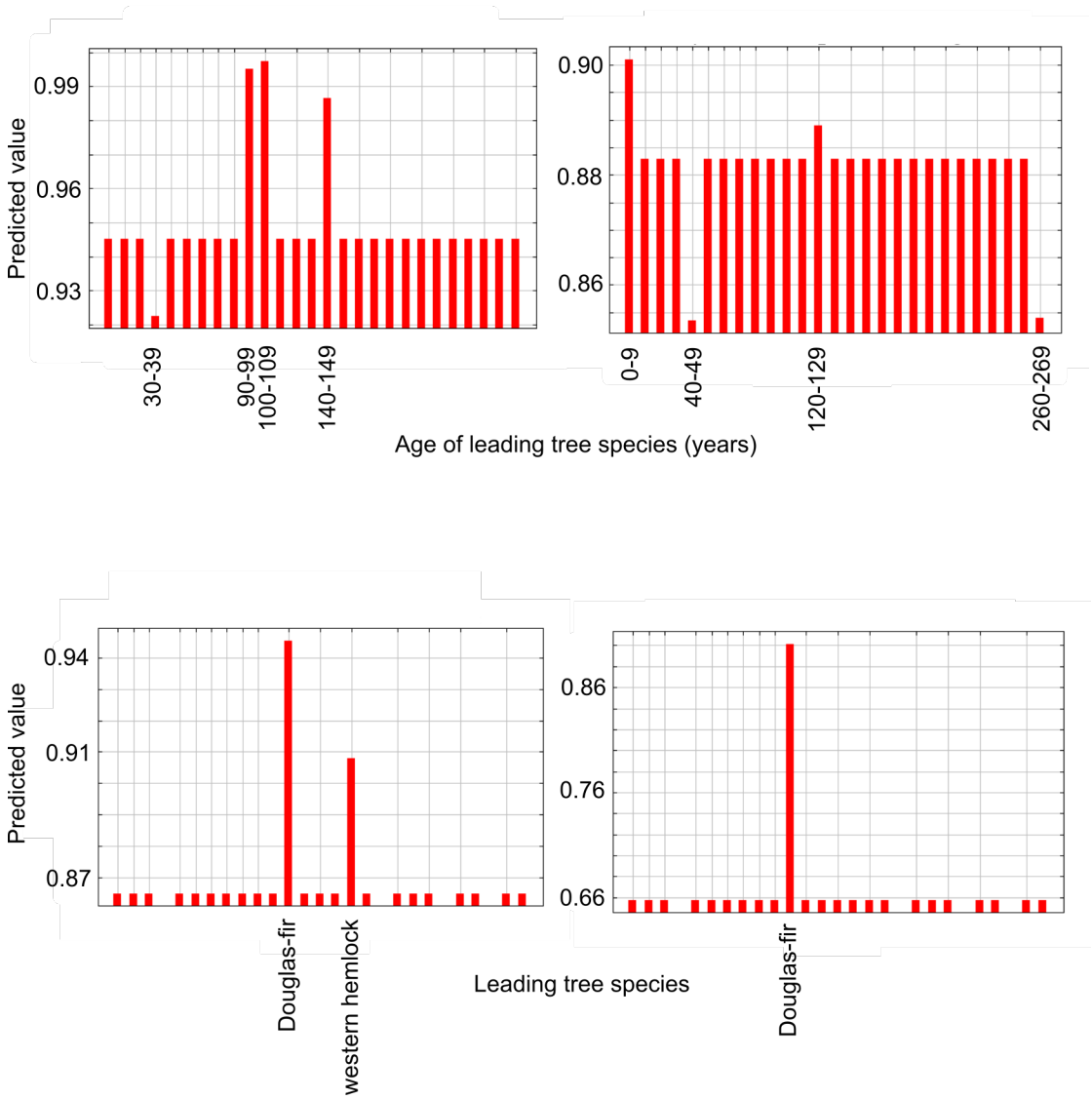


Figure 2.7. Response curves for environmental variables in the a) “Field” and b) “Verbal” models. Y-axis values indicate probability of suitable habitat predicted (1.0 equals 100%). Note: y-axis scales differ between models, except for the variable “Elevation”.

2.4.3. Model Performance

Area under the curve (AUC) values for the “Field” (0.920) and “Verbal” (0.923) scenarios demonstrated that both models effectively discriminated between pine mushroom presence and absence conditions, and both are more effective at identifying suitable pine mushroom habitat than a random model distribution. These values are also are considerably higher than the minimum AUC considered suitable for conservation planning (0.70) (Elith et al., 2006). Omission error rates are also low and comparable between models, at 0.054 for “Field” and 0.062 for “Verbal”, giving a strong indication that both models correctly identified the extent of suitable habitat in Líl̓wat territory based on the training data (ie. the occurrence records).

While high AUC values and low omission rates indicate both models provide reliable predictions, the slightly lower omission rate, and the higher cumulative threshold (35.852) set by the “Field” scenario suggests that “Field” is the better model (Table 2.3). In other words, any given location within the study area must be at least 35.852% suitable, according to the “Field” model, to be included in the predicted suitable habitat—a value almost 10% higher than the threshold set by the “Verbal” model (26.593%). A higher threshold results in a more conservative suitable habitat prediction. This may be the more desirable scenario to use if there are costly trade-offs between managing for pine mushroom habitat and other land uses.

Table 2.4. Metrics indicating the minimum level of suitability set by each model to be predicted as suitable habitat (cumulative threshold), as well as each model’s ability to correctly identify absences (omission error), and discriminate between presence and absence (AUC).

Model	Cumulative threshold (%)	Omission error	Area under the curve (AUC)
“Field”	35.852	0.054	0.920
“Verbal”	26.593	0.062	0.923

2.5. Discussion

2.5.1. Value of Indigenous Knowledge in Species Modeling

The strength of predictions made by both models indicates that IK can yield sound occurrence data, overcoming a significant challenge associated with modeling the distributions of rare and elusive species, such as the pine mushroom. The high degree of similarity between model predictions and model performance also suggests that field-based occurrence data may not be necessary to predict species distributions. As noted in the methods section, however, Líl̓wat pine mushroom experts assisted with site selection for both scenarios to varying degrees, thus the "Field" scenario is not solely based on data gathered from randomly selected sites. For this reason, the similarity between model outputs and the emphasis on elevation as a primary predictor of habitat suitability should be used a point for further investigation and not the basis for absolute conclusions.

Other studies attest to the versatility of IK in overcoming some of the challenges inherent to species modeling. For example, Anadón et al (2009) concluded that local ecological knowledge collected through interviews not only yielded high-quality data, but was also a cost effective solution when modeling the abundance of terrestrial tortoises (*Testudo graeca*). Some regions may be difficult to access and/or the species of interest may be rare—cases in which IK has provided otherwise unattainable information regarding species distributions (Luizza, Wakie, Evangelista, & Jarnevich, 2016; Skroblin et al., 2019). Polfus, Heinemeyer, & Hebblewhite (2014) observed the predictive power of IK, where IK yielded predictions similar to, if not more conservative than, generalized linear mixed-models. In a comprehensive review of studies spanning a range of geographic locations, spatial scales, and both terrestrial and aquatic environments, Bélisle et al. (2018) concluded that local knowledge provides an unmatched level of precision, particularly when compared with field studies whose scope is time and budget-limited.

2.5.2. Challenges of Modeling with Indigenous Knowledge

While Líl̓wat knowledge of pine mushrooms played a critical role in the feasibility of gathering occurrence data for this study, which covers a large area and for which there was minimal

budget, the process of incorporating Líl̓wat knowledge was not without challenges. IK arises from collective observations over space and time (Peloquin & Berkes, 2009) while field-derived occurrence data typically used in modeling is spatially precise and temporally static. Thus, a major challenge was configuring Líl̓wat IK to work within the limitations of a species distribution model. Instead of standardizing field-based and IK-derived occurrences—which encompass different spatial and temporal scales--I stratified the two into separate datasets. Even more significant was the challenge of accessing knowledge for use in modeling. Indigenous knowledge of pine mushrooms is no longer widely held by Líl̓wat people due to colonial policies such as residential schools that disrupted knowledge transmission (see Chapter 3). A history of exploitative research has also created feelings of suspicion towards researchers and the need to guard intellectual property (Leo et al., 2006). Finding Líl̓wat pine mushroom experts, and demonstrating my trustworthiness as a researcher took time and considerable effort.

Indigenous knowledge (IK) is also inherently biased, as it arises from practical experience and is used to meet practical needs (Peloquin & Berkes, 2009). While sampling bias is not uncommon in SDM studies of rare species, qualitative methods may be required to minimize or account for biased data elicited from IK. For example, while each mushroom picker shared a slightly different set of occurrence localities based on their own preferred picking areas, the validity of these locations can be cross-referenced against the fact that in most cases, each of these locations was used and passed down from previous generations (A.Joseph, personal communication, 20 August, 2020). Thus, bias within IK may be more effectively evaluated using methodologies and theoretical frameworks more familiar with IK production and transmission.

2.5.3. Contextualizing Model Results in Ecocultural Terms

In spite of the challenges, incorporating IK in SDM not only enriches and addresses data gaps, but also provides context to model results that grounds abstract mathematical values in more culturally relevant terms. For example, while evidence shows that Líl̓wat people travelled extensively throughout their territory for food gathering and other cultural activities (Líl̓wat Nation, 2006), most documented permanent and seasonal settlements are located at lower elevations near rivers and lakes (Líl̓wat Nation, 2010a) and overlap with areas predicted by both models as suitable pine mushroom habitat. These results are consistent with other resource

mapping studies that draw from Indigenous knowledge, where resource availability is not simply a matter of biophysical suitability but also community needs, such as accessibility, resource quality and safety (Benner et al., 2019; Peloquin & Berkes, 2009; Rossier, 2019). Proximity to historic human settlement and the long-record of Líl̓wat presence in their territory, which dates back to 2260 BC (Líl̓wat Nation, 2010b), suggests pine mushroom habitat formed part of the larger resource basket that both shaped and was shaped by, the harvesting activities of Líl̓wat people. Líl̓wat people also emphasize the role of wildlife, and deer, in particular, in spore dispersion. The most skilled mushroom pickers follow deer[7] movement, as deer seek out and eat pine mushrooms in the fall. Deer and rodent were the most common animal signs of browsing on pine mushrooms in the Oregon Cascades (Pilz, Smith, Amaranthus, & Alexander, 1999). Deer, in particular, "can be effective agents of long-distance dispersal" (Cázares & Trappe, 1994, p. 509). By spreading fungal spores via their feces (Cázares & Trappe, 1994) and likely their fur, deer may influence pine mushroom distribution over years of migrating to winter range within the same elevation band described by our model results[8].

Framing pine mushroom habitat suitability in ecocultural terms provides a more holistic picture of the complex interactions at play. While my model results indicate a linear relationship between elevation and pine mushroom probability, Indigenous knowledge indicates that Líl̓wat use and a healthy deer population may also be important for long-term pine mushroom sustainability. My findings also suggest that the importance of elevation as a predictor variable, even if not explicitly identified by Líl̓wat people, is already embedded within Líl̓wat IK of pine mushrooms. Broader, conceptual questions emerge: for example, if IK is capable of predicting species distributions without computer-based models, then what role(s) can scientific modeling play that IK does not already? Studies that focus on achieving complementarity between information obtained from science and IK as unique and incomparable knowledge sources over identifying points of concordance (Huntington et al 2004), or discordance (Peloquin & Berkes, 2009; Rossier, 2019), are more likely to access the full potential of all data sources (Mackinson,

[7] In Lil'wat territory, the primary deer species are mule deer (Odocoileus hemionus) related subspecies Columbian black-tailed deer (Odocoileus hemionus ssp. Columbianus) (Bunnell, 1990)

[8] Mule deer winter range extends up to 900 m on the coast (Nyberg & Janz, 1990), and up to 1500m in shallow to moderate snowpack zones in the interior of BC (Armleder, Dawson, & Thompson, 1986). It is likely that within Lil'wat territory deer winter range falls somewhere in between, with habits influenced by both coastal and interior deer populations (D.Guertin, personal communication, 14 October, 2020).

2001). Where IK typically focuses on a spatial scale from one to tens of kilometers, scientific data and models can enable information and analysis at broader scales on the order of hundreds to thousands of kilometers (Huntington, Suydam, & Rosenberg, 2004; Mackinson, 2001). IK is also not static, constantly adapting to incorporate new observations and experiences (Menzies & Butler, 2006; Peloquin & Berkes, 2009; Polfus et al., 2014). When knowledge production through academic research is conducted in respectful and reciprocal ways—including obtaining Free, Prior and Informed Consent (FPIC)[9] at all stages of the research—both IK and science can benefit. New information gathered through collaborative studies can be added to the local knowledge base—as was the case amongst Indigenous beluga whale hunters in Alaska (Fernandez-Gimenez et al., 2006). According to the hunters the "scientists are beginning to think like us", and when "they see themselves as part of it and not separate from it ... there are gains on both sides'." (Ibid, pp. 311-312). Researchers are "witnesses" to environmental phenomena (A. Watson, 2013), and in addition to contributing new information, can help document and increase the visibility of important ecological issues in formats more readily acknowledged by non-Indigenous legal or administrative institutions.

2.5.4. Recommendations for Future Work

Continuing to record occurrence data of pine mushrooms in Líl̓wat territory would enable Líl̓wat Nation to monitor the state of this resource in the face of competing land uses, as well as climate change. A larger dataset would reduce model stochasticity, and increase the reproducibility of the model outputs. Another option is to explore a different modeling approach, such as Bayesian belief, to derive predictor variables from Indigenous knowledge and produce community-defined metrics for optimal habitat suitability.

[9]FPIC is described as the conditions under which consent from Indigenous peoples for a project, plan or action should be obtained: 1) prior to the implementation of a decision or action, 2) free from coercion, intimidation or manipulation, and 3) based on timely, accurate and culturally appropriate information (Food and Agriculture Organization of the United Nations 2016).

2.6. Conclusion

In addition to meeting Líl̓wat community needs for pine mushroom habitat data, my study offers insights to support the growing interest in incorporating IK into SDM. For elusive species in particular, IK can provide a sound source of otherwise inaccessible occurrence data to enable modeling and mapping suitable habitat. In addition to contending with technical challenges of working with IK, such as bias, accessing IK requires that scientists earn the trust of the communities with whom they are working. This may involve a community-based approach to setting research objectives and engaging with IK according to culturally-defined protocols. The process is involved, but yields benefits to both researchers and communities, including meaningful research relationships and richer spatial data to support Indigenous-led land stewardship.

Chapter 3: An eco-cultural study of pine mushroom habitat and place on Líl̓wat Traditional Territory

3.1. Introduction

The description and taxing of 'minor forest produce', a forerunner of the recent term, 'non-timber forest products', goes back at least to mediaeval times (Hoover & Hoover, 1950). 'Minor forest produce' were formally named and managed in all the editions of the *Forest Department Code* of the Government of India, from the first edition (Government of India, 1877) to the present day. Parts II to IV of Volume 5 of the magisterial *Schlich's Manual of Forestry* are devoted to 'minor forest produce' (Fisher, 1908). The Food and Agriculture Organization (FAO) opted for the term 'non-wood forest products' (NWFP), formalized as a priority area in 1991 (Food and Agriculture Organization of the United Nations, 2020).

Introduced by de Beer & McDermott (1989), the term, "non-timber forest products", (NTFP), is now as widely used as FAO's 'NWFP'. Where local peoples experience the economic benefits of NTFPs much more directly than those of timber, the rights to which are more often held by large companies (Davidson-Hunt, Duchesne, & Zasada, 2001), formalizing NTFPs as part of the forest economy was presented as a solution to overcoming poverty and conservation challenges (Belcher & Vantomme, 2003; Shanley, Cymerys, Serra, & Medina, 2011). Initially applied to tropical and subtropical forests, by the 1990's, the NTFP concept gained traction in boreal and cold temperate forest regions, including Canada, where wild mushrooms were being increasingly harvested at commercial levels (Ibid).

Among the most commonly harvested NTFP species, pine mushrooms (*Tricholoma spp.*) present the greatest value to the Canadian economy. Thousands of seasonal jobs (Ehlers et al., 2007), as well as millions of dollars in export value (Tedder, 2008; Wills & Lipsey, 1999) result from pine mushroom harvesting. In addition to Canada, pine mushroom species are native to regions of Japan, China, the Korean peninsula, Mexico, and the United States. In the 1980's pine mushrooms gained fame as a globalized commodity. The decline in domestic supply in Japan drove demand for closely related species from other regions, including the province of British Columbia (BC), spurring entrepreneurial mushroom hunters to flood small communities,

bringing to mind the 1850's gold rushes (Amaranthus et al., 2000; Gamiet et al., 1998; Kaesuk Yoon, 1992; Mitchell et al., 2010). With no regulations on harvest or access (Hamilton, 2012; Mitchell et al., 2010; Tedder, 2008), mushroom pickers traveled from near and far, indiscriminately traversing the forest and often raking away the moss and forest floor (Mitchell et al 2010; Yoon 1992) to expose the youngest and most valuable mushroom fruiting stage— the "button" (Figure 3.1), and in the process damaging the mycelium required for future fruiting. The flurry of activity put increased pressure on the forest and on local communities (Kaesuk Yoon, 1992; Tedder, 2008), prompting numerous studies, working groups, and research institutes, resulting in policy recommendations to manage pine mushrooms as a diversified source of forest revenue (Gamiet et al., 1998; Hamilton, 2012; Mitchell et al., 2010).

Figure 3.1. A potential "#1" or "button" pine mushroom, with veil still intact (left). Harvesting lower grade pine mushrooms with veils broken, possibly of grade 4 or 5 (right). Low-grade mushrooms are also known as "flags". There are six possible grades assigned to pine mushrooms by commercial mushroom buyers in British Columbia (de Geus, 1995).

While the NTFP framework increases the economic visibility of pine mushrooms, the lack of regulation in BC puts at risk the social and cultural values of Indigenous peoples for whom pine mushrooms hold non-economic significance (Davidson-Hunt et al., 2001; N. J. Turner, 2001). The forest is at the centre of a way of life for many Indigenous peoples in BC, to the extent that Indigenous law scholar Deborah Curran argues for ecosystem health as the foundation for Aboriginal rights and title (Curran, 2017). Anthropologists and ethnoecologists emphasize that landscapes are cultural spaces (Lepofsky et al., 2017; Long, Lake, & Lynn, 2018; N. J. Turner, 2001), proposing terms such as "cultural keystone species" (Garibaldi & Turner, 2004)and

“cultural keystone places” (Cuerrier, Turner, Gomes, Garibaldi, & Downing, 2015). Just as certain species are the keystone of entire ecosystems, so too are natural features integral to entire cultures. The forest is not simply a source of “saleable products”, but a “breadbasket, a medicine chest, a toolbox, a building supply store, a training centre, and a home” (Collier & Hobby, 2010, p. 2). In contrast, a sole focus on the economic value of pine mushrooms risks over-exploitation, and reducing complex forest ecosystems into discrete, extractable commodities. Turner (2001) points to examples such as the careless and excessive harvest of cascara (*Rhamnus purshianus*) in the 1930’s and 1940’s, and more recently, the over-harvest of huckleberry (*Vaccinium mebranaceum*) for commercial export, and Pacific yew (*Taxus brevifolia*) for corporate pharmaceutical use (N. J. Turner, 2001). The issue is not human activity per se, as Indigenous peoples (IP) in North America have a long history of promoting pine mushroom growth for increased productivity (Anderson & Lake, 2013b; Kuhnlein & Turner, 1991; Menzies, 2006). Rather, the issue is one of narrowness of focus; of reducing a whole forest to isolate for its parts in the interest of intensive resource extraction and commodification.

Unlike the NTFP framework, an ecocultural framework presents a more holistic approach to understanding and valuing pine mushrooms and other forest species. Early introductions to the ecocultural concept emerged from within the ecological restoration literature, and has since been applied to forest resource management (Long et al 2018). Similar to the socio-ecological system concept (Ostrom, 2007), ecocultural system analysis acknowledges the dynamic interplay between social institutions and ecosystems in creating resilience, but with greater attention to the unique cultural context of Indigenous communities in particular (Pretty, 2011).

The Indigenous ecocultural context of this study is that of the Líl̓wat people in British Columbia, Canada. Líl̓wat7úl— the “real, original [Líl̓wat] people of Mount Currie”, British Columbia (Kennedy, Bouchard, & Mack, 2010, p. 224), have resided on their territory (Figure 3.2) since time out of mind. Under the Indian Act of Canada (from 1876) and the Canadian legal system, Líl̓wat7úl (herein referred to as “Líl̓wat people”) are known collectively as Líl̓wat First Nation (formerly Mount Currie Indian Band). Stories of supernatural beings the Transformers, explain the establishment of territorial boundaries and trade relationships between Líl̓wat and neighbouring Sṯáṯyemc peoples to the east (Ibid). This history clarifies that although Líl̓wat people share ancestral ties with the Sṯáṯyemc, Líl̓wat Nation asserts itself as a distinct Nation with exclusive rights to the land and resources within their territory (Líl̓wat Nation, 2006). The Líl̓wat Nation Botanical Resources Strategy describes some of the forest resources present in

Líl̓wat territory and their cultural significance, but Líl̓wat Nation also maintains that all species matter (Líl̓wat Nation, 2006). Pine mushrooms have become a species of particular concern as Líl̓wat territory includes some of the most productive pine mushroom habitat in British Columbia (Wiensczyk & Berch, 2001), attracting significant interest from non-Líl̓wat mushroom pickers (J.Gabriel and K.Tindall, personal communication, January 25, 2019). The same habitat supports commercially important timber species, including Douglas-fir (*Pseudotsuga menziesii*). The implications of these conflicting interests are addressed in this chapter, as part of the larger ecocultural analysis of pine mushrooms within Líl̓wat territory.

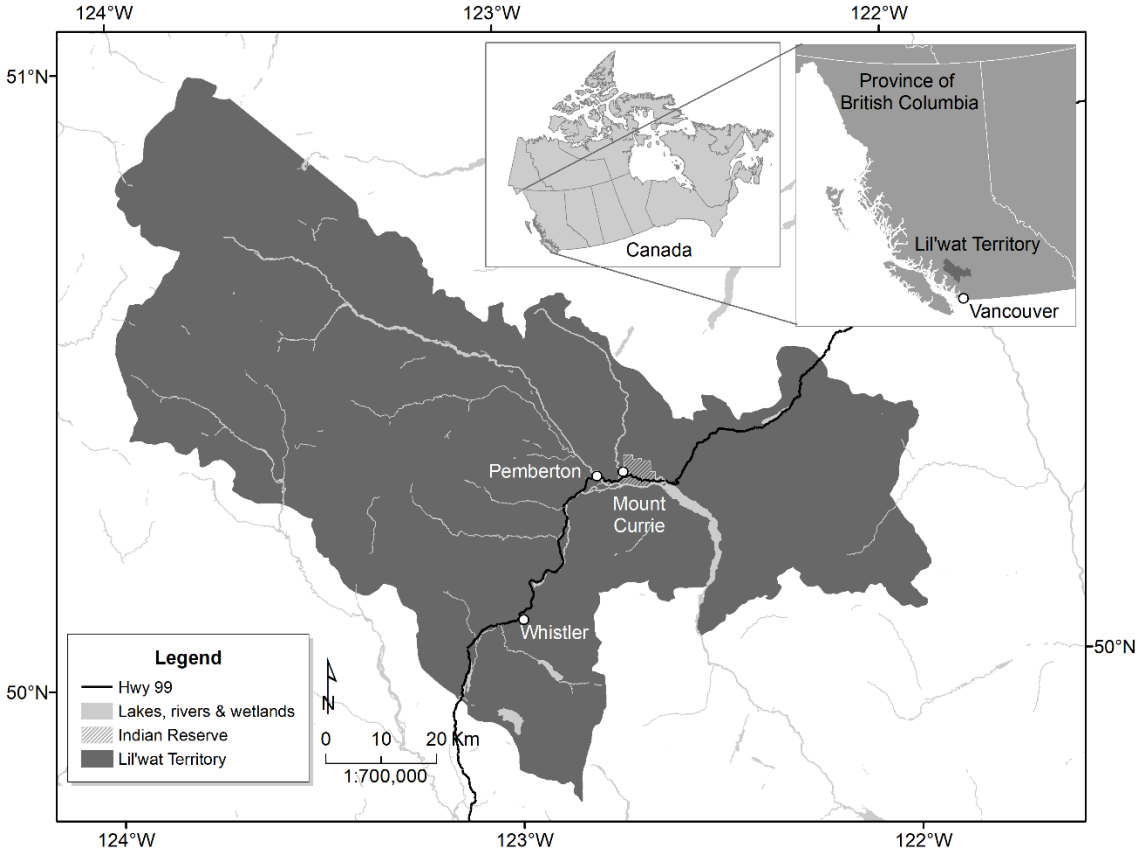


Figure 3.2. The study area, Lil'wat traditional territory, in British Columbia, Canada.

3.2. Research Objectives

The core objective of this chapter is to make visible the non-economic values of pine mushrooms to Líl̓wat people, which includes but is not limited to documenting Líl̓wat ethnomycology. Using an ecocultural theoretical framework, I explore the ways in which pine

mushrooms and their management by Líl̓wat people are not simply a matter of economic development, but of cultural identity. Through interviews, participant observation, and document analysis, I triangulate between these multiple sources of information to address the following questions:

1) What is the significance of pine mushrooms to Líl̓wat people?
2) How are/were pine mushrooms managed by Líl̓wat people?
3) What is needed to safeguard Líl̓wat interests in pine mushrooms?

3.3. Methodologies and Methods

3.3.1. Methodologies

O'Leary & Hunt (2017) argue that qualitative data do not necessarily need to be representative in order to be effective. Qualitative data can instead be used to achieve "relativeness" and develop "rich understanding" (Ibid, p. 384). Two qualitative research methodologies guided this study: grounded theory (Charmaz, 2006) and Indigenous methodologies. In grounded theory, research questions and themes emerge from the data over the course of the research process, wherein data collection and analysis happen simultaneously (Ibid). The data can also generate "leads" (Ibid), which both define and refine the search for further data. By focusing on "theory construction, not for population representativeness" (Ibid, p. 6), grounded theory also accommodates small sample sizes. I used the concept of "information power" (Malterud et al., 2016) to ensure sufficient, high-quality data was collected. Greater information power comes from including varied experience within the specific target group or experiences not previously described (sample specificity), deriving data from high quality dialogue, applying in-depth analysis, and linking to and building on established theories (Ibid).

An Indigenous research methodology is a mode of inquiry that prioritizes the concerns of and benefits to Indigenous peoples, as well as acknowledges the inherently subjective and political nature of research as a product of the cultural framework in which it operates (Denzin & Lincoln, 2017). Internal reflection, discussions with Líl̓wat collaborators and community members, and engagement with the S7ì̓stken Líl̓wat Research Protocol (Leo et al., 2006)provided guidance as to whether the study and iterations of research questions foregrounded the needs and ideas of

the Líl̓wat community. Jordon Gabriel acted as the Líl̓wat Nation collaborator in the study and provided regular guidance on the study's objectives, research questions and scope. Research in this chapter also draws on multiple ways of knowing, including Líl̓wat Indigenous knowledge, in recognition that randomized experiments are not the sole means of constructing truth (House, 2006).

3.3.2. Methods

3.3.2.1. Data Collection and Analysis

I sourced data for this study using three primary methods: 1) semi-structured interviews, 2) participant observation, and 3) document analysis.

3.3.2.2. Interviews

I interviewed a small, but varied group of four experienced Líl̓wat mushroom pickers separately in 1-1.5 hour sessions, each. Interviews took place in fall of 2019. In this study, the informants' collective experience directly harvesting mushrooms total over 150 years. The source of their collective knowledge, however, spans millennia, as archaeological evidence dates Líl̓wat presence in their territory back to 2260 BC (Líl̓wat Nation, 2010b). Interview questions were reviewed in advance by the primary Líl̓wat collaborator, Jordon Gabriel (Appendix 1). Informants were not randomly selected, but following Mackinson (2001), identified based on depth and uniqueness of experience, as well as the respect shown them from within community. Interviews were conducted at a place and time convenient to informants. I conducted the first interview with Jordon Gabriel present and the remaining three interviews alone. Figure 3.3 summarizes the collective demographic profile of the Líl̓wat mushroom pickers interviewed. Each interview was audio-recorded with the informant's consent, along with some written notes. I transcribed each interview manually, semi-verbatim, in Microsoft Word.

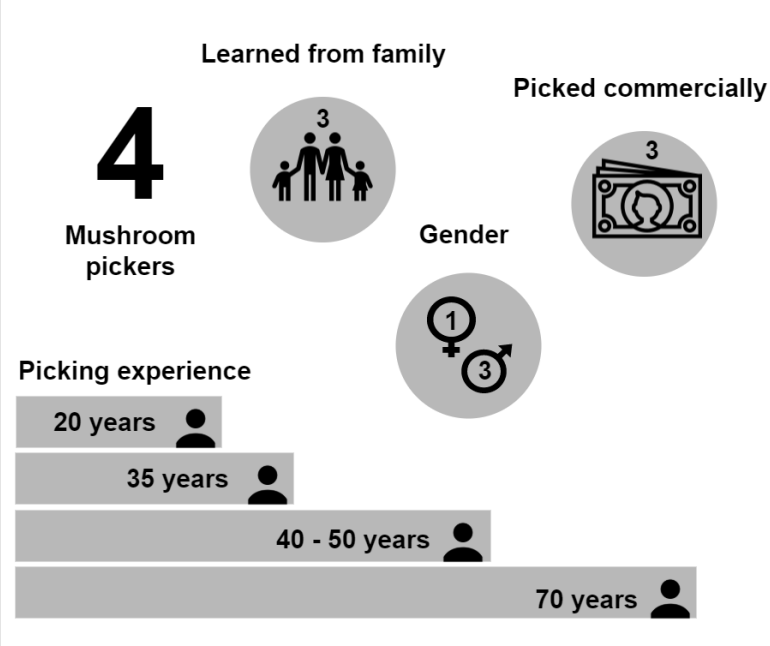


Figure 3.3. Summary of interviewee demographics. Summary values are indicated in circle icons. Each interviewee's level of experience picking pine mushrooms is indicated in bar icons.

I coded each interview in two cycles (Saldaña, 2015). The first cycle consisted of process coding, which involves identifying examples of participant actions and interactions, routines and rituals within the text (Ibid). In the second cycle, I organized initial process codes into conceptually similar groups, yielding a shorter, more focused list of codes. Themes were then identified from second cycle codes. I identified a total of 41 process codes, 29 focused codes, and four themes (Appendix 2).

"Codable moments", (Saldaña, 2015, p. 16) found in quotes from interviewees and documents, provided illustrative evidence to support the themes identified, and are organized by relevance to each research question in Results.

3.3.2.3. Participant Observation

Participant observation also occurred during Fall 2019, over the course of five trips to the Líl̓wat community, ranging from 3-7 days each. Activities included helping community members to collect wild food and medicines unrelated to mushrooms, cooking and eating together, preserving collected pine mushrooms for later use, and socializing during periods of inactivity.

Interviews and trips into the forest were enriched by personal perspectives and experiences shared by community members during long drives to and from picking and data collection sites. There were also several spontaneous and informal conversations with community members to whom I was introduced while passing through the Líl̓wat Nation offices or gas station, as well as with friends and family of community members with whom I spent the most time.

Early into my field work, Jordon Gabriel and I organized a community meeting on 2 October 2019 to provide information on the project in general and attract interest from local mushroom pickers in particular. We advertised the evening event through social media, and word of mouth, provided dinner, and shared preliminary mapping of potential pine mushroom habitat. Six people attended, including Gélpcal Cultural Chief Ashley Joseph, and participated in an unstructured conversation about pine mushrooms. Before that meeting, Jordon and I met with Chief Joseph in late September 2019, who over the course of an hour shared his knowledge of and approach to pine mushroom stewardship and the importance of pine mushrooms to Líl̓wat people.

I synthesized the vast and rich information shared with me as an illustrated conceptual diagram (Figure 3.4), visually depicting the ecocultural mycosystem of the pine mushroom according to community accounts. In late November 2019, I joined a table hosted by Líl̓wat Forestry Ventures and a community economic development open house, and distributed copies of my illustration to Líl̓wat community members, and shared a photo slide show of our field work.

I developed friendships with several of the people I have met through this study, and the time we spent together provided important context, opportunities for data collection through embodied learning, as well as acted as an additional accountability mechanism for keeping Líl̓wat needs and interests at the forefront.

Although participant observation yielded data, recorded as handwritten notes, this method was primarily used to provide context for analyzing, validating and triangulating between data gathered through interviews and document analysis.

3.3.2.4. Document Analysis

To supplement the interview and participant observation data, I conducted a literature search to

identify documents about Líl̓wat management of and concerns over forest resources in their territory that met the following criteria:

1. are publicly available
2. represent a collective voice of the Líl̓wat community
3. included the entire Líl̓wat Traditional Territory in their geographic scope
4. represented Líl̓wat community members and the collective community voice with high fidelity, and
5. were addressed, at least in part, to outside institutions and with the intent of influencing decision-making processes

I identified seven documents (Appendix 3) that met all of the above criteria, including three policy documents and one fact booklet produced by Líl̓wat Nation, one Doctor of Philosophy dissertation, one ethnographic book, and one law research institute report. I then coded these documents in a manner similar to the interviews to identify primary themes. Although the documents I reviewed included quotations from or interviews with multiple informants, I analysed each document as a representation of one unified voice.

Coffey describes documents as doing "work"— persuading, validating and justifying, among other purposes — and containing tacit information about a setting and the document's function (Coffey, 2014). I applied an 'interview technique' (O'Leary & Hunt, 2017) to elicit both explicit and tacit data from the documents analysed, generating both content and context.

3.4. Results & Discussion

Below, I discuss results by research question and theme. Direct quotations from transcribed interviews are attributed by anonymous participant code (e.g. "Interviewee 1") and denoted with a superscript plus sign($^{+}$). Direct quotations cited from secondary data are attributed to the original source, as noted in the publication where it is featured. All quotations are italicized. Data gathered through participant observation and reflecting my interpretations and observations, or informal conversations, are denoted with an asterisk (*).

3.4.1. Research question 1: What is the significance of pine mushrooms?

Two key themes emerged when investigating what is the significance of pine mushrooms to Líl̓wat people: 1) living as Líl̓wat, and 2) fighting and resisting.

3.4.1.1. Living as Líl̓wat

Linguistic clues suggest that not only mushrooms, but pine mushrooms in particular, were an important feature of traditional Líl̓wat daily life. Being named stands as evidence that a species is "sufficiently recognized" within a culture (Menzies, 2006, p. 93). That specific names exist for different mushroom species in Ucwalmícwts, the Líl̓wat languge, including pine mushrooms, demonstrates a high level of recognition.

Kuhnlein and Turner reported that pine mushrooms were gathered "in large quantities" by not only Nlaka'pamux-speaking peoples, but also Upper Halkomelem[10], and Lillooet Interior Salish— of which, Líl̓wat Nation is a part (Kuhnlein & Turner, 1991, p. 26). In the case of Nlaka'pamux, and Lillooet Interior Salish dialects of their respective language families, the same name is given to pine mushrooms as for mushrooms in general (Kuhnlein & Turner, 1991). While Ucwalmícwts, the Líl̓wat language, is part of the Lillooet Interior Salish language family, nine[11] Ucwalmícwts-specific and two Lillooet[12] words to identify mushrooms have been documented:

1. q̓em̓s, or sq̓em̓s - "edible mushrooms that grow under or near fir trees", also "pine mushroom, mushroom, fungus"
2. smet̓áqa7 - another term for "an edible mushroom that grows under cottonwood or near fir trees"
3. nláw7aqw - "kind of mushroom that grows when sockeye [lawa7] runs"

[10] Upper Halkomelem is a dialectic group of Salishan-speaking peoples, spoken as far north as present-day Yale, to present-day Mission and Abbotsford area (Gardner, 2009).
[11] Words 1-8 are from Joseph et al. (2013), with corrections provided by Ucwalmícwts language experts Veronika Bikadi and Priscilla Ritchie. Word #9 is from the Líl̓wat Nation recipe book (Líl̓wat Nation, 2020). Words #10-11 are from Van Eijk (2013).
[12] van Eijk (20013) notes "Lillooet" is a language spoken in two "mutually intelligible" dialects, centered geographically around either Mount Currie (Líl̓wat Nation) or Fountain (Xaxli'p First Nation).

4. melcqín - “mushroom growing under cottonwood”, also “unidentified type of mushroom”
5. lhétca7 - “a mushroom with a slimy top [*Hygrophorus eburneus*]”
6. q̓eḿsálqw - “mushroom on a tree”
7. séĺnats - “a fungus that grows underneath logs and is used as medicine”
8. cweĺalhpúlḿecw - “puff balls, a type of fungus”
9. gwelgweĺeleń - “morel mushroom”
10. ḱm-us - “(A) ‘edge of a cliff or steep sidehill;’ (B) ‘Unidentified species of mushroom’ “,
11. n.waq̀-q^{w} - A type of mushroom with a concave top… probably covering both *Lactarius resimus* and *Lactarius torminosus*.”

Most documented phrases[13] that relate to mushroom picking, however, use q̓eḿs as the word for mushroom, and only in one case is meant to specify pine mushrooms (underlines added for emphasis):

1. q̓welén lhkacw tákem i sq̓eḿsa nskwámem lhkúnsa - you cook all the mushrooms I got today
2. xáĺem stúmchas ti nskúz7a cwílėm ku sq̓eḿs - my child made me climb the hill to look for mushrooms
3. npzáḿqánlhkan i wa7 q̓eḿsam - I caught up to the one’s picking pine mushrooms
4. cúywi malh ńas ihkalh tákem q̓éḿsam - come on we are all going mushrooming
5. kwálhaḿts7as ti nskuz7a kwet ńas q̓eḿsam - me child invited me to go along with her mushrooming
6. tsektsákluḿcw ti tmícwa cw7it i q̓eḿsa - the ground is cold there is a lot of mushrooms
7. púnem aylh i cw7ita - “to find a whole bunch (e.g., berries, roots, mushrooms)”

The synonymous use of “q̓eḿs” or “sq̓eḿs” to refer to both pine mushrooms and edible mushrooms in general, suggests that pine mushrooms may have been the default choice for consumable mushroom species in Líl̓wat territory and thus, a fixture in the diversity of seasonal foods relied upon by Líl̓wat people.

The relatively high standing of pine mushrooms in Líl̓wat culture can also be seen in the number

[13] Phrases 1-7 are from Joseph et al. (2013), with corrections provided by Ucwalmícwts language experts Veronika Bikadi and Priscilla Ritchie..

of cultural sites that are either named themselves, or contain named places, bearing in mind that once more, *a named place… holds special cultural importance for [Líl̓wat] people* (Líl̓wat Nation, 2006, p. 63).

The Traditional Territory has a wealth of mushroom species. These fungi include all four of the primary wild food mushrooms; pine mushrooms, chanterelles, morels, and boletes (Líl̓wat Nation, 2006, p. 27) Pine mushroom, however, is the only species specifically identified among the following places where mushrooms were traditionally gathered (Líl̓wat Nation, 2006)[14]:

- K'zúzalt (Twin Two)
- Mkwal'ts (Ure, or Boulder, Creek, the beach where the creek meets Lillooet Lake)
- Emhátkwa (Green River below Mount Currie, also "Clearwater")
- Ntsítsugwten (Cheakamus River)
- Sp'ó7ez' (Rubble Creek)
- Nsk'enú7 (Above Lillooet Lake)
- Lil'wáta Tselálh (Lillooet Lake)

Many of these places were used not only for mushroom and other food gathering, but overlapped with nearby village sites, deer migration areas (where hunting takes place), and Transformer routes (explained below) (Líl̓wat Nation, 2006). There is a deep history of pine mushroom harvesting, as demonstrated above by the visibility of this species in documented Líl̓wat words and cultural sites. This history of pine mushroom use evidently overlaps with other important aspects of Líl̓wat life as well. I was consistently advised that deer, and other wildlife, eat and spread the spores of pine mushrooms, and as such are excellent guides for finding pine mushroom patches*. Deer hunting takes place in the fall, during two important events that make them easier to find: mass migration from summer to winter habitat, and the rut when males congregate to compete for female mates and exude a distinct scent. Becoming familiar with these and other cues makes for more successful hunting and mushrooming, strengthens knowledge of and relationship with "the land", and affirms connections to heritage, culture and community. Líl̓wat interviewees explain:

[14] Additions and corrections to place name details provided by Ucwalmícwts language experts Veronika Bikadi and Priscilla Ritchie.

It was all part of the harvest, and to me the moose, the deer, the bears, they're all within the same area, and in the later season…when you're out there long enough and you're connected to the land, it's fricken amazing, you can't explain it. Whereas you can smell the mushrooms, you can smell "oh there's a creek nearby", you can smell a bear, you can smell a moose, you can smell the deer, you can tell if it's male or female[+]*. (Interview 3, October 21, 2019)*

…my grandpa was out there when it was raining and he would go camp up there he does the hunting first, hunting at the same time not first but then he'd sit there at the campfire and then he'd go out into the bush a little bit when the moon is shining and he'd say look at all the moss. He could see the moss moving, really slow and then he'd check when it was daybreak and it was a mushroom, 'cuz he said when it's a full moon they seem to pop up faster[+]*. (Interview 4, November 26, 2019)*

...my other one my granny was saying, when she looks out on the hill just here, the one across the river here, if you see it all foggy in there like it's all white or even across there, anywhere where you see the white like fog then she said oh we should go there, she said there must be some mushrooms in there, gets the moss all moist all the misty air[+]*. (Interview 4, November 26, 2019)*

I started, we used to go picking huckleberries, that was up at [local place name][15] *there, they said, we used to come back down and my mom and dad used to find them on the flats and we used to go and help harvest them*[+]*. (Interview 1, October 3, 2019)*

*…sometimes it's almost second nature to smell it, when you've been out there for so long, you know. It gets like that when you're hunting, like you can smell the deer. Pass through. Then we go harvest the, what do you call it, the hákwa7 [*wild rhubarb, cow parsnip or *Heracleum maximum*] *and that. And the grizzly bears go through there and you can smell them on the bushes*[+]*. (Interview 1, October 3, 2019)*

One place I went back here, cuz I got home from logging one day, early, my friend told me he went there somewhere, so I went to look and I was finding buttons this size, under the moss. He said they're under the moss, you just have to go look. And I found them. But I got a spooky

[15] Place name redacted at the request of Líl̓wat Nation.

feeling so I left…I was talking to [a friend] last night he was saying maybe there's a grave site back there or something, spirit or something…it could be like, a family. Certain families are buried there. They won't get bothered. Some guys don't get bothered but some guys, they can sense it more than other people[†]*. (Interview 1, October 3, 2019)*

My father in law showed me one place when we first started going. He said, "come in here". He was walking in the deep, black thimbleberry bushes…He said "nobody usually comes in here" he says. He shows me[†]*. (Interview 1, October 3, 2019)*

I brought my friend and I wanted to show him because he was my friend, I didn't think he was greedy, and then all we found was #1's. I can't even remember the year, 20 years ago, but I'm learning that they come in spurts. And, for my trick, I hate to tell everyone my tricks, but I prefer waiting for the leaves to fall off. When it's better.

In sum, pine mushroom harvesting is not done indiscriminately by Líl̓wat people. Care is taken to find the right place and moment in any given year, and to cultivate or maintain social fabric within families and the community on the whole. Even where harvesting has shifted towards commercial sale, the practices implemented fundamentally originate from and reinforce what it means to be Ucwalmícw, Ll̓il̓wat7úl, "the people of the land" (Squamish Líl̓wat Cultural Centre 2019). For a list of specific management practices utilized, see section 3.3.2.

Necessary to being Ll̓il̓wat7úl, however, is the freedom of self-determination. Líl̓wat Nation's Strategic Plan includes in its objectives: *maximum personal economic choice and opportunity*, and *maximum control over Líl̓wat Traditional Territory* (Líl̓wat Nation, 2016, pp. 7-8). The Líl̓wat Land Use Plan underlines this point: *cultural activities are critical to the well being of our people* (Líl̓wat Nation, 2006, p. 32). The document also points to the inherent link between botanical resources use and cultural activities: *pick[ing] and shar[ing] botanical resources with elders to support community gatherings, ceremonies, and other cultural events* (Líl̓wat Nation, 2006, p. 28), a sentiment that is echoed across other St̓át̓yemc Nations:

The Canadian government has attempted to extinguish us (our title and rights), to sever our obligations to the land, the plants, the animals, the medicines and ties to one another. No more! We rise above in unity and embrace sovereignty and the right to self-determination…Even the practices of fishing, hunting, gathering and trading have a fundamental role that helps create the

foundation of St'át'imc sovereignty and self-determination, by showing us that culture and biodiversity –the human and the natural world –are not separate. In fact, they are interdependent and constitute self-determination) ((St'át'imc Chiefs Council & West Coast Environmental Law, 2018, pp. 5-6).

Pine mushrooms are one pathway towards self-determination, providing opportunities to simultaneously reconnect with Líl̓wat teachings and practices for "being on the land", as well as enabling alternative access to the money economy.

Interviewee 3, although taught by Sam Peters and other Elders more versed in traditional ways of harvesting, saw a significant opportunity when commercial prices were high, and earned enough to build a house and become financially independent. In their own words:

I seen an opportunity for me, myself, and I[+]*. (Interview 3, October 21, 2019)*

For Interviewee 1, when the commercial price per pound for pine mushrooms was high, the additional income earned from picking mushrooms was enough to support their family on those cash earnings, alone. The earnings, however, were not sustainable enough to justify leaving a regular paid position and even in "boom" times, they limited their picking to weekends*. As I write this thesis (March 2021), the price per pound for pine mushrooms given by local mushroom buyers averages between CAD$10-$20 per pound for the highest grade mushrooms, that is "#1's". In the pine mushroom "gold rush" in the 1970's through the early 1990's, for example, pickers could earn upwards of CAD$123 (1988 dollars) or more per pound (Mitchell et al., 2010), or as much as CAD$1,000 (1978 dollars) "on a good day" (Gamiet et al., 1998). In spite of the significant decline in price, Interviewee 1, along with many other Líl̓wat people with varying degrees of knowledge and skill in harvesting pine mushrooms, continue to go searching for and picking pine mushrooms. Motivations appear to vary. Interviewee 3 insists that many people sell pine mushrooms to satisfy *their fix*[+], but it is not clear whether their use of this term is a critique of lifestyle choice— for example, working at a job, shopping, making car payments, etc., versus more traditional activities practiced by those whom Interviewee 3 refers to as *the real people*[+]. In spite of their critiques, Interviewee 3 also notes that whether through income earned from a job or mushroom picking, both have afforded more Líl̓wat people the ability to purchase vehicles and thus, travel further on the Territory and *connect to the land** *(October 21, 2019)*. In other words, the economic gain of pine mushrooms is means to a more culturally

significant end.

The exclusion, harassment, fines, and a multitude of other barriers Líl̓wat people have faced, and often continue to face, in order to live according to their culture and on their Territory, offer a different perspective on the importance of pine mushrooms to Líl̓wat people. Beyond a non-timber forest product, pine mushrooms are a medium for cultural revitalization, financial independence, and a sense of personal pride.

3.4.1.2. Fighting and Resisting

'Fighting and resisting' reflects the outward work in which Líl̓wat people have been engaged since the arrival of Europeans to their territory in 1793 (Líl̓wat Nation, 2010b). The Declaration of the Lillooet Tribe (1911), of which Líl̓wat Nation was part, contests specific acts against them but more broadly contests and resists claims by British Columbia to their land and resources:

We are aware the B.C. government claims our country, like all other Indian territories in B.C.; but we deny their right to it. We never gave it nor sold it to them. They certainly never got the title to the country from us, neither by agreement nor conquest, and none other than us could have any right to give them title. (Chiefs of the Lillooet Tribe 1911)

To this day, Líl̓wat people contest British Columbia's jurisdiction over their territory and assert their sovereignty, through acts of resistance that take many different forms. Here I argue that one such act of resistance is the harvesting, use and stewardship of sq̓em̓s, also known by its scientific and common names, *Tricholoma murrillianum* Singer*,* and pine mushroom, respectively.

St̓át̓yemc Elder Desmond Peter Jr succinctly summarizes the irony and injustice of a system that now requires Indigenous peoples to prove their use and occupancy of lands over the same time period that it previously prohibited them from entering, let alone use (Zabawa, 2013).

The whole system is flawed because you can put down a date like 1846 and at the same time, they put you on reserve and tell you can't leave the reserve to use your territory. How can you maintain use? (Desmond Peter Jr 2017, as cited in Zabawa, 2013*, p. 154)*

Líl̓wat experiences highlight how Canadian legal orders such as the Indian Act, confinement to Indian Reserves, and land preemption, and policies such as the residential school system, grossly interfered with and continue to affect Líl̓wat people's ability to be physically present on their Traditional Territory and learn or share the knowledge needed to practice their customary land uses.

And before our people just stayed within the boundaries. Well, being a ward of the government, they weren't allowed. They were actually sneaking in a sense …my dad, if he got caught making wood by uniformed inspector of the force or whatever, or his redneck buddy told on him, it was a racist, biased thing. He was tongue-lashed and in court…they were like stealing their own wood[+]. (Interview 3, October 21, 2019).

There's so much land out there and if you go and use the land, they say no, you can't touch it. It's happening now it worries me for the young ones now, what's going to happen for the future[+]. (Interview 4, November 26, 2019).

But when this country has done the things to my people that it's done, and when a person like myself witnesses and lives with those things, we try to find ways to bring [out] our plight. We try to find justice because we believe that we are not getting it. (Qwetminak Mary Williams 1991, as cited in Crompton, 2006).

The Province of British Columbia continues its pattern of excluding Líl̓wat people from their lands, both by claiming Líl̓wat territory as "Crown land" and issuing permits for land uses that, in most cases, preclude cultural uses.

The government of British Columbia has been providing "Crown land" for private development, which often has been inappropriate (Líl̓wat Nation, 2006, p. 53).

Intensive logging and other major developments have altered most of the forest and plant ecosystems in the Traditional Territory, and the use of pesticides and herbicides has damaged our plant resources (Líl̓wat Nation, 2006, p. 27).

Most suitable pine mushroom habitat in Líl̓wat territory is claimed as Crown land, where the provincial government controls all decisions about land access and use. Trees may not be cut

without authorization from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development under the *Forest Act* (1996). The *Wildfire Act* (2004) restricts the size and type of fires that may be lit without a burning registration. There is an expectation to report burning activities to wildfire management agencies, even with fires that may not require registration (Boutsalis, 2020).

Government policies and regulation have also affected Líl̓wat access to resources, including the inability to practice vegetation burning to regrow important plants and attract wildlife (Líl̓wat Nation, 2006, p. 34).

Through forest tenure acquisition Líl̓wat Nation is gaining increasing direct control over forest management in their Territory. However their practices are still constrained by legislation defined and enforced by the Crown. Although by participating in the forest tenure system and complying with provincial law, Líl̓wat Nation is arguably validating provincial jurisdiction over their Territory, the alternative is to forego much-needed community economic income from logging and wait possibly decades or longer until disputes over Líl̓wat title are resolved. Another interpretation is that securing forest tenure and participating in related systems are interim steps to secure the financial resources and influence that might lead to more transformative change.

As Líl̓wat Nation government engages in forest tenure-related processes to assert their rights, Líl̓wat people are engaged, quite literally, at the ground level, contesting Crown sovereignty by practicing customary uses of the land, such as pine mushroom harvesting. Pine mushrooms form part of the larger cultural landscape over which Líl̓wat people have and continue to demonstrate continuous use, assert their heritage and right to govern. “Being on the land”, a commonly used phrase to describe spending time in remote parts of the territory to hunt or collect food, medicines and materials, is also an act of cognitive resistance. In spite of pressures to assimilate into White Canadian society, Líl̓wat people continue to harvest pine mushrooms for food, the maintenance of social fabric, and as part of the local economy. As one interviewee explained:

Now they’re getting the taste for “this really is our country, this really is our land, this really is our territory”. And that’s the one great thing I like about it, is they’re getting out there[+]*. (Interview 3, October 21, 2019)*

The logging industry started expanding in the 1940s and became the largest industry in the Meadows. Although native people had kept their traditional ways along with subsistence agriculture by this time, their life had been largely modified by white settlers with the introduction of the money economy (Nemoto, 1998, p. 66).

Thus, the act of being physically present on Líl̓wat territory, of leaving Reserve boundaries to harvest pine mushrooms and other wild food and medicines, is resistance through body and mind.

3.4.2. Research question 2: How were/are pine mushrooms managed?

Indigenous land management typically regards resource use as a function of social responsibility. There is history between people and their place, and that history defines who they are, as well as the duties they must uphold as a condition of belonging.

In Líl̓wat Territory, these duties were first defined by the Transformers, a group of supernatural siblings who arrived after The Great Flood, defining geographic and social boundaries, as well as providing moral and practical life lessons (Mack 1987, as cited in Kennedy et al., 2010). Physical reminders of these lessons are widespread on the Territory— for example, rocks that were once people and were transformed when they failed to behave as expected. In the version of the story recorded by James Teit the unnamed narrator tells that two of the Transformers are the founders of Sla'tlemux (Sṯát̓yemc) and Li'leut (Líl̓wat) peoples, respectively, with the Sṯát̓yemc being situated east of the mountains that drain into the Birkenhead River, and the Líl̓wat being situated south of the mountains (Teit, 1912). Although considered distinct from Líl̓wat, Sṯát̓imc peoples also attribute the Transformers as the originators of the principles that govern how to "live on the land and do things properly" (St'át'imc Chiefs Council & West Coast Environmental Law, 2018) . According to Sṯát̓imc Law:

The work of the Transformers and active St'át'imc management created the ecological conditions that all beings in St'át'imc territory need to thrive; St'át'imc law requires that these conditions be maintained or restored (St'át'imc Chiefs Council & West Coast Environmental Law, 2018).

It is from the lessons imparted by the Transformers, originally transmitted through stories from

one generation to the next, that the Líl̓wat principles of k'úl'tsam̓ (*take only what food we need*) and k'ul'antsút (*take only what materials we need*) were developed. These ideas fall under a broader set of guidelines, Ntákmen (*Our Way*) and N'ékmen (Our Laws), that outline what it means to be Líl̓wat7úl, including upholding collective responsibilities in all aspects of life. It is in this social context that Líl̓wat pine mushroom management should be understood: not as management interventions to optimize use of a specific resource, but "as individual practices encoded in institutional arrangements" (Peloquin & Berkes, 2009, p. 534). Wyatt (2008) makes a strong case for approaching natural resource management as a socio-cultural exercise and not just a technocratic one, pointing out that forests are cultural landscapes and not simply part of the timber harvesting landbase (THLB). Líl̓wat Nation explains:

Our cultural beliefs dictate that we do not own the land; we are here to protect it. We practice conservation and respect for the Traditional Territory, as witnessed by our ways of collecting plants and harvesting animals to meet the needs of our people, while respecting the needs of the natural system (Líl̓wat Nation, 2006).

Several examples of pine mushroom harvesting and use given during interviews, observed through participation and noted in the Líl̓wat Nation Recipe Book (Líl̓wat Nation, 2020)[16], highlight the prominence of reciprocity in customary Líl̓wat pine mushroom management. Among the specific practices are*:

- Not "raking" the soil to avoid damaging the mushroom mycelium
- Covering or filling in holes exposed after a mushroom is picked
- Shaking the mushroom or lightly tapping the cap as you pick it to release spores and promote more mushroom fruiting
- Leaving behind, crushing, or breaking apart and dispersing the pieces of rotten mushroom to release spores and promote fruiting
- Walking on deer trails to prevent trampling mushrooms[RB]
- Not over-picking; listening to your conscience for when to stop picking
- Sharing the mushroom harvest in a way that extends the benefit to as many people as possible, for example by cooking in soup
- Preserving mushrooms by drying (and, in contemporary times, freezing) to avoid waste,

[16] Examples cited from the Líl̓wat Recipe Book are noted by superscript [RB]

and in preparation for less abundant future harvest

- Observing animals, weather phenomenon and changes in phenology
- Looking for “candy stick fungus” (*Allotropa virgata*) as an indicator of pine mushrooms[RB]
- Picking safely (don’t go alone, wear red for visibility and protection, know what you are picking)[RB]
- Leaving the forest before it gets dark; by then mother nature must take care of herself and cannot take care of you
- Leaving an offering, such as tobacco[RB]

Figure 3.4. A conceptual diagram of the Líl̓wat ecocultural mycosystem, based on information shared with the author during this study.

What we do when we're picking all the time I and my sister "Oh that's overripe" and we just leave it there. We don't smash them we just leave it back under the moss…If a person's never been there before you got to tell them all I said, not to rake it or overdo the moss just like you're doing go get your mushroom out and then you cover it. Or you can shake the mushroom to let the spores come out, ones that are open not the button, the open ones you just shake it in and then cover it again. So that'll be there for the next year…If you over pick them it takes a few

years before they'll come back[+]*. (Interview 4, November 26, 2019)*

As noted by Interviewee 4, sharing knowledge and teaching are important elements of the Líl̓wat pine mushroom management system, but in contemporary times doing so comes with extra challenges. Prior to the intergenerational traumas incurred by the residential and/or day school systems, in particular, children would learn from their parents, Elders and other family members by listening, watching and participating in livelihood activities, such as mushroom harvesting.

Well how I learned all my picking of mushrooms is from my granny, my grand uncle's, my mom and dad, and other friends…I was listening, sitting down cuz we were young kids not like kids now who are constantly running around or on their [phone]…they were talking our language and we would listen to them[+]*. (Interview 4, November 26, 2019)*

In contrast, Interviewees 1 and 3 did not learn most, if any, of their knowledge about pine mushroom harvesting until they were adults*. Interviewee 3, among other Líl̓wat mushroom harvesters I met that are of a similar age, were forced to attend residential school. Consequently, not only were they denied the opportunity to learn their language, culture, and customary practices while in residential or day school, they suffered physical and psychological abuse simply for being Indigenous*. Conversations about residential school were initiated by the Líl̓wat people I spent time with, sometimes while talking about or doing activities related to pine mushrooms, and other times not. What is evident, however, is that without the underlying cultural and social fabric that assimilation measures such as residential schools set out to dissolve, Líl̓wat land and resource management systems were destabilized. As one person explained: residential school reoriented Líl̓wat people's values from 'giving' to 'taking'* (September 27, 2019). While high commercial prices for pine mushrooms during the 1990's allowed some Líl̓wat people to earn a great a deal of money (eg. as much as CAD$600,000 in a year, or enough to build a large house using cash, alone), the mushroom gold rush created tension between what another person described as a 'reflective, traditional' approach to one that is focused on economic development* (September 27, 2019). While the promise of high earnings has created a strong incentive for Líl̓wat people to 'be on the land", without the emphasis on social responsibility that traditional Líl̓wat teachings and values promote, there is risk of degrading future pine mushroom availability for short-term gain over long-term stewardship.

It's nice they're getting out there, but they're not putting it away, like [the cutting and preserving] we're doing here, doing now. They're not doing that. Why? This is worth [CAD]$100/lb in Japan. Kinda understandable. It's 2019+. (Interview 3, October 21, 2019)

I just haven't seen them get to be big number 5's anymore 'cuz people pick them sooner. Bigger you see them is probably 3's, and 4's if you're lucky+. (Interview 1, October 3, 2019)

In 1984 Clarke was in Williams Lake. They were talking about non-timber forest products, such as mushrooms. They wanted to harvest it for employment. Clarke said they missed the point; mushrooms are important to all life. (Sʔáʔimc Elder Clarke Smith 2017, as paraphrased in Sʔáʔimc Chiefs Council and West Coast Environmental Law 2018, p. 106)

On November 4, 2019, a community member was giving us a brief tour of a preferred mushroom picking spot that is close to the Reserve. Upon arrival they were shocked to find that much of the area had been "raked"— that is, the moss had been torn away from the ground in what looked like a frenzied manner. The community member shared that not long before, they had taken out a group of Líl̓wat youth to teach them about pine mushroom harvesting and stewardship. They suspected that the youth came back without their knowledge, with the intention of harvesting as much as they could in order to sell. They were disheartened to see the youth had not really grasped the real importance of their lessons. This example suggests that while there are certain physical and environmental conditions necessary for pine mushrooms on Líl̓wat Territory to survive, the socio-cultural conditions necessary for Líl̓wat pine mushroom knowledge and stewardship to survive are just as important.

Reciprocity with other people and reciprocity with the land are values that seem to counter the problematic land management practices that typically accompany harvesting primarily for short-term economic gain. Similar observations have been made amongst other Indigenous communities for whom pine mushrooms form part of the traditional diet. Although young pine mushrooms, known as "buttons", fetch the highest commercial price per pound, in Kuhnlein & Turner (1991), a Nlaka'pamux woman waited until the mushrooms she found had matured before harvesting. In California, Karuk and Yarok peoples implement many of the same harvesting and stewardship strategies noted above by Líl̓wat mushroom pickers, including moderating harvest, avoiding damage to mycelium, and promoting the growth of fruiting bodies

by leaving behind rotten mushrooms or dispersing mushroom pieces and therefore spores (Anderson & Lake, 2013a). Pine mushroom spores are most abundant 3-4 days after the "veil" of the mushroom is torn (Park & Ka, 2010)— that is, when the mushroom is biggest but no longer at its highest commercial value. Such mushrooms are known as "flags", or "3's, 4's and 5's" (Figure 3.1). Interviewee 3 talks about Líl̓wat Elder Sam Peters, who taught them to how to find and pick "flags":

...our people were simple. The more volume, it wasn't about the money. It was like bringing home another form of food, vegetable, like bringing the wife flowers. Figure of speech. And um, like Sam Peters, when we met him out there, he was so simple and down to Earth, he only picked enough to get his cigarettes and gas up his motorbike and go to town, and maybe go back 30 miles and grab his case of beer and enjoy it. It was so simple for him, like he never, he only had 10lbs, which got him [CAD] $150, give or take, and he was content, he wasn't chasing the almighty dollar….nobody knew the territory more than him, and he knew exactly where to go. But when the time comes and he has all these mushrooms, and they're big flags, #3's, 4's and 5's, we taught him about how to find the #1's, the ones that you cannot see[+]*. (Interview 3, October 21, 2019)*

While Sam Peters taught Interviewee 3 and their peers how to harvest mushrooms to meet customary needs— that is, for personal consumption— the favour was returned in kind when they taught Sam Peters which size of mushrooms to harvest as part of the pine mushroom money economy.

Interviewee 4 discusses the importance of sharing, both the labour and the bounty, in pine mushroom harvesting:

Interviewee 4:

..they used to come back with a big pack. And then when they did come home, my mom, well we were young then, then my mom and other people, all the ladies would gather around the table like this and they'd all clean the mushrooms and one would be cleaning, the other would be slicing, the other would be stringing them on a string or something and hang them behind the stove 'cuz we didn't have no dehydrator then. So they'd hang them behind the cook stove or above the stove.

…they'll cook it right away only enough for self, for yourself and to feed all the family and everything and then, all the ladies would call each other, and they'd help each other, with anything.

…some of [the mushrooms] they fried it up with onions but most of the time they'd put it in soup. So everyone else would get some+. (Interview 4, November 26, 2019)

While Interviewee 4 noted that *nobody shares anymore+* (Ibid), they also commented on noticing a shift where increasingly they are receiving gifts of pine mushrooms, deer liver and deer meat, along with requests from community members living as far away as Vancouver for advice and medicinal plants to treat various ailments. In other words, the ethic of sharing is one of several Líl̓wat values being revitalized through pine mushrooms and other forest resources.

It was not uncommon to hear from Líl̓wat people that they or their family members did not like the smell or taste of pine mushrooms. Nevertheless, pine mushrooms are harvested, keeping in mind those that do eat them, as noted by Interviewee 1:

…we try and leave it for the elderly ones, the flat areas, sometimes we try and leave it for them, but if they don't show up then we go look in there. But usually if they say they're going in there, we try to leave it for them…My mother-in-law goes, but she goes to the [topographically] flat parts too so…One of us usually goes with the mother-in-law, or she takes her sisters too.

…the wife doesn't like the smell in the house, when they're cooked. We usually just give them to the mother-in-law, or the brother-in-law, when we go visit, if I want to eat some with them+. (Interview 1, October 3, 2019)

If we found any pine mushrooms during our field work it was emphasized that they should be harvested and shared with others in the community. Through pine mushroom and other resource harvesting, Líl̓wat people are adapting traditional values such as reciprocity to fit contemporary needs, and demonstrating that social responsibility continues to be a core component of Líl̓wat resource use and stewardship.

3.4.3. Research question 3: What is needed to safeguard Líl̓wat interests?

The above sections describe how Líl̓wat interests in pine mushrooms are grounded in resistance to colonialism, cultural revitalization, and strengthening social fabric. While Líl̓wat people are no longer prohibited from leaving the reserve, colonial policies continue to restrict access to mushroom picking through administrative, environmental and cognitive means. Here I explore examples of each.

Administrative barriers to pine mushroom and other traditional resource gathering have restricted Líl̓wat access since 1859, when all lands in British Columbia were claimed as "Crown" land. A year or less later, the *Preemption Act* of 1860 allowed British subjects to pre-empt[17] land for eventual fee-simple private ownership, while Indigenous peoples were prohibited from land preemption. Shortly thereafter, the Land Ordinance of 1865 established a timber leasing system, assigning control over timber rights—and arguably, over the future of forest-dependent species— to the Governor of British Columbia. New forms of tenure were introduced and administered by a ministry of the British Columbia government, such as the tree farm licence (TFL) and forest licence (FL), but their "evergreen" licence structure enabled de facto forestland privatization and control over forest management by private companies, subject to forest regulations (Clogg, 1999). In 2006, Líl̓wat Nation established its own forestry company, "Líl̓wat Forestry Ventures" (LFV) to manage newly acquired tenure made available to First Nations under the "Forest Revitalization Plan" (T. Smith & Bulkan, 2021). Currently LFV holds 20% of the forest tenure by volume in Líl̓wat territory (T. Smith & Bulkan, 2021). For the remaining 80%, proponents[18] must engage with Líl̓wat Nation through a referrals process. While this process provides the Nation with an avenue to contest proposed logging, they do not have veto power where conflicts with understory botanical resources are concerned. Few, if any, opportunities exist to contest private land use activities. The result is the historic and continued loss of pine mushroom and other resource gathering areas to non-Líl̓wat entities and interests. Interviewee 4 expressed their concern:

Yeah It's really hard now because it's up here, like Mosquito [lake] where, or Ivey [lake] where,

[17] Pre-emption was an incentive system used by the provincial government to encourage surveying, settlement and land cultivation. Following these "improvements", claimants were able to buy the land at a discounted price and granted title for private ownership.
[18] A proponent is a party applying to the Province of British Columbia for a licence to engage in an activity under provincial jurisdiction—for example, to harvest timber.

where Tonya lives, we used to go hunting there and we used to go pick mushrooms there. Now all the houses are going in up there, everywhere up there, right up to Mackenzie…We go up towards, well I don't know what they call, went through Mosquito here to the Ivey, went on the wagon right through to Mackenzie on the wagon. There was only wagon roads, there was no such wide openings…Yeah you can't even go hunting up there anymore, you can't even go looking for mushrooms up there. It's a favourite place for everybody to go. I think that's what's going to happen across when we're going to Boulder, there are going to be houses going in there sometime". (Interview 4, November 26, 2019)

Nwal'ts (Mosquito lake) is a named place that Interviewee 4 notes is also preferred traditional hunting and mushroom-picking grounds, used since at least the time of travel by wagon road. Located close to Mount Currie, where most Líl̓wat community members live, and even closer to historic settlement sites, conversion of mushroom grounds to private development in the Nwal'ts area is arguably a significant loss for the community. Since most of the land use in the territory is not under direct Líl̓wat control, the fear that other places may suffer the same fate is understandable. Interviewee 4 adds that logging is another activity which is responsible for the loss of well-used mushroom-picking sites:

There's a lot of places right now that they're logging and then my brother and other people says they were going to go back there and pick and then they were just cussing after " hey, they logged out there where we were picking mushrooms". Yeah my brother [name removed], did that same, not only him, there's other people that went and not only them, me and my sister we went up this way, got to the place and it was just all logged out! (Interview 4, November 26, 2019)

Community frustration over the loss of mushroom-picking sites was, in fact, the impetus for Líl̓wat Forestry Venture (LFV) to commission this graduate research. Applying a culturally-minded approach to planning and implementing logging and other forestry activities is a priority for LFV. However their decision-making is limited to the areas covered by their forest concession licences (Smith and Bulkan 2021). As a small company, and without legal authority over their customary territory, which is held exclusively by the Province of BC, LFV is largely constrained to "business-as-usual" forestry, which means fulfilling the Allowable Annual Cut of timber determined by the Ministry (T. Smith & Bulkan, 2021). Provincial regulations that enable Líl̓wat Nation to have pine mushroom picking areas supersede more extractive uses, such as

timber, could help overcome this conundrum, However past attempts at regulating NTFP's in BC have failed, as lack of, or changes in, political will led to policies and regulations fading into the background or being repealed (Hamilton, 2012; Tedder, 2008). Transferring land tenure and resource access, alone, will not address what Long and Lake (2018) refer to as "socio-ecological traps" that interfere with customary land stewardship by Indigenous peoples. Erosion of traditional knowledge and the social fabric within which resource use is embedded are cited as equally significant barriers (Ibid). Thus, overcoming administrative access, alone, is an insufficient solution.

Other more complex barriers such as climate change, and what I propose here as "cognitive access"— that is, the erosion of cultural value and knowledge surrounding pine mushrooms, require additional measures.

One interviewee insists that pine mushrooms are resilient enough to withstand climate change: *Climate change. I don't think it has anything to do with it. I believe it's the mushrooms have their own thinking pattern* ⁺ (Interview 3, October 21, 2019). While that may be true, there is already evidence that frequently used picking spots may not be as productive or as reliable as they once were:

We haven't been finding any there, not as much as we used to. I don't know what's happening there...I think it's just drier, I think. It's an old creek bed like, but we haven't seen any water there yet ⁺*.* (Interview 1, Oct 3, 2019)

In conversation with the Líl̓wat research team member, Interviewee 1 adds more detail:

JG: *Last year there was just about no season, because it was dry, right, and then we got the early snow.*

Interviewee 1: *Early snow and then whatever ones we found were mostly wormy or something.* (Ibid)

JG: *Snow melted, then the snow came and stayed, right, early. Nobody really got to go pick* ⁺*.*

It is predicted that ecosystems in British Columbia could shift up in elevation by as much as 455

meters, and further northward up to 278 kilometers (Wang, Campbell, O'Neill, & Aitken, 2012). Ecological implications for Líl̓wat people are made more complex by the fact that Líl̓wat territory is situated in what is considered a "transitional" zone, influenced by both coastal and interior climate conditions. Drier, interior, ecosystems are expected to double in extent, while the extent of coastal ecosystems will not change significantly (Wang et al., 2012). As discussed in Chapter 2, in section 2.2.3 Suitable Habitat, pine mushrooms on Líl̓wat territory are found in both interior and coastal-type ecosystems, namely the CWHds1* and IDFww subzones* (Berch & Wiensczyk, 2001). Both feature warm, dry summers and moist, cool winters (Green & Klinka, 1994)—a nuanced set of conditions that meet the needs for both the pine mushroom's underground mycelium (warm and dry) and fruiting bodies (cool and moist) to develop (Gamiet et al., 1998). Disruptions to climate conditions needed to support either life stage, in either the coastal or interior pine mushroom ecosystem types, could mean fewer pine mushrooms, or none at all.

As a global phenomenon, climate change cannot be attributed to any one activity. Policies at a more local scale, however, can exacerbate the effects of climate change and hinder the resilience of ecosystems and communities to adapt. Non-timber values, including pine mushrooms, can only be prioritized under British Columbia forest legislation, as long as the action does not "unduly reduce the supply of timber" (West Coast Environmental Law, 2004). A timber-first approach to forest management in British Columbia most often involves a variation of clearcut logging (Environmental Reporting BC, 2021)and replanting to create more structurally uniform forests. In contrast, intact* forests are inherently more adaptive and resilient to climate change, and among other ecosystem services, reduce the risks and buffer the effects of drought (J. E. M. Watson et al., 2018).

Experienced mushroom pickers are accustomed to the inherent variability of weather and pine mushrooms— for example, Interviewee 1 notes, *If it's too dry, we usually go look in the creek beds, where the gullies are. It's more moist there. S*uch adaptive management, however, requires intimate familiarity with the landscape. Peloquin and Berkes (2009) argue that generations of living with and adapting to variability is one reason why Indigenous knowledge is so resilient. The authors argue that while there is no "pre-knowledge" of climate change, nor of what specific changes might result, generations of living with and understanding ecological complexity equips Indigenous knowledge-holders to be able to respond to the uncertainties of climate change (Peloquin & Berkes, 2009). Thus, the valuing and transmission of customary

knowledge about pine mushrooms is essential for Líl̓wat people to continue accessing pine mushrooms in the face of climate change. Most obviously, customary knowledge is needed to find the mushrooms, which can be elusive as to when and where they appear. In the previous section, Líl̓wat community members cited observing wildlife movement, phenological changes, fog, and other indicators to locate pine mushrooms. Other knowledge cited concerns about sustaining mushroom productivity over the long-term. Interviews and participant observation indicate that few community members are well-versed in both types of knowledge, however:

So there are some mountains where everyone's trained to go pick at their certain spots and they go to the same spots, and it's sad to say, I see some of our people, they're still wandering around trying to get lucky+. (Interview 3, October 21, 2019)

EDY: …*even though people may not know all these things about the mushrooms, the fact that they started picking...Do you think that's good? Or what do you think about that?*

Interviewee 4: *I don't know it depends if they're going to do it cuz not much of them are doing anything+.* (Interview 4, November 26, 2019)

Knowledge of how to "be on the land" safely is another issue. For example, Interviewee 1 advised:

[We] just go usually for the day, depending on what time we get up and try to get home before dark, anyway…For safety reasons and so you don't have to get search and rescue coming up for you….It's happened a time or two. It's mostly, it gets too dark for people to come back down. They get lost+. (Interview 1, October 3, 2019)

In a different conversation, Gélpcal Cultural Chief Ashley Joseph explained that leaving by 3:00 pm is important because that is the time that mother nature needs to take care of herself; she cannot take care of you anymore* (September 27, 2019).

When prices are high, however, caution can sometimes be overshadowed by a strong sense of opportunity. Multiple community members described continuing to pick after dark, navigating with headlamps back to their trucks, and having to persuade themselves to stop in spite of the mushroom abundance. For experienced pickers and hunters, skilled at navigation and

seasoned at making judgment calls about timing and weather, the result can be as harmless as a good story to tell. Other cases, however, can lead to tragedy. Mushroom picking-related fatalities within the Líl̓wat community occur on average every five years and are attributed to lack of familiarity with site conditions and/or lack of preparedness*. Líl̓wat knowledge was customarily passed from one generation to the next through children listening, watching and spending time with adults in their community—through oral history and embodied learning. Forced removal of children from their families and homes during the Residential School era disrupted traditional Líl̓wat knowledge transmission, leaving many residential school survivors estranged from their families and territory and without knowledge of how to "be on the land". Líl̓wat Nation is actively engaged in revitalizing their culture through the Skalúla7 Rediscovery Camp, the Ucwalmícwts language immersion program and adult classes (Líl̓wat Nation, 2015), and reintroducing cultural burning (J. Gabriel, personal communication, July 2020). The relative effectiveness of such efforts in increasing cultural cognitive access may be limited by Provincial government policies that are built on colonial values, however, including laws that prioritize resource development over environmental protection and which limit land use activities and decision-making by Indigenous communities.

3.5. Conclusion

As discussed in this chapter, Indigenous communities, such as Líl̓wat Nation have generations of practical experience integrating culture and resource management for long term sustainability. This study explored examples as they relate specifically to pine mushrooms, demonstrating the deep history and place of pine mushrooms in Líl̓wat traditional life and social systems. The data also revealed the ways in which colonial policies have and continue to affect multifaceted Líl̓wat access to pine mushrooms. Themes that emerged offer an Indigenous, ecocultural lens through which to value pine mushrooms: as a medium for resisting colonization, revitalizing cultural identity and pursuing self-determination. This approach stands in contrast to economically oriented rationales for non-timber resource management, and timber-first forest management policies.

Section 3 of the recent B.C. Declaration on the Rights of Indigenous Peoples Act (DRIPA) (2019) stipulates, "the government must take all measures necessary to ensure the laws of British Columbia are consistent with the Declaration". Forestry is cited as a "tangible" starting point for operationalizing DRIPA (Alexander, in Linnit, 2019). However recent professional

development events hosted by the Association of BC Forest Professionals (ABCFP)[19] suggest that forestry professionals are confounded by what such legislative changes might look like in practice. The results of this study suggest DRIPA can be put into practice by, first, seeking to understand the deep cultural significance that forest resources hold for Indigenous peoples in BC— not simply for their utility, but for their value in affirming identity and a way of life. The provincial government has committed to meaningful multistakeholder processes with rightsholders – the Indigenous Peoples – and other stakeholders, in the legislative revision processes. Further, species more sensitive to anthropogenic forest disturbances, such as the pine mushroom, may stand as a benchmark for achieving both ecological and cultural integrity within forest management.

[19] The events referred to here are a webinar given July 27, 2020 by Sandy Carpenter, LLB, "The United Nations Declaration on the Rights of Indigenous Peoples and Making the Declaration Law in Canada for Forestry Professionals", and Q&A session held February 6, 2020 with Paul Craven, Superintendent of Professional Governance, during the 2020 ABCFP conference.

Chapter 4: Conclusions

4.1. Review of Research Objectives and Questions

In this thesis I focused on one elusive, ectomycorrhizal, forest fungi species, *Tricholoma murrillianum* (pine mushroom), and its situation within the ecocultural context of the Líl̓wat Nation, in British Columbia, Canada. While only recently traded as a global commodity, pine mushrooms have long been known to Líl̓wat people as a component of their traditional diet. Recognizing that the productivity of pine mushroom habitat is put at risk by logging and indiscriminate mushroom picking, prompted the Líl̓wat Nation to commission research that would generate spatial data of pine mushroom habitat in their traditional territory. Thus, the first goal of my research was to collaborate with and support the Líl̓wat Nation in their efforts to steward pine mushroom habitat in their traditional territory. Given the challenges of modeling rare species distributions, and the detailed Indigenous knowledge (IK) already held by Líl̓wat pine mushroom harvesters, my second goal was to test the use of Indigenous knowledge in species distribution modelling, thus overcoming occurrence data limitations. In addition to spatial data, documentation of traditional management and use provides powerful evidence to assert rights and title to customarily held and managed lands. Thus, my third goal was to explore the value of pine mushrooms to Líl̓wat people, as articulated by harvesting and stewardship practices. Finally, international policies such as the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) and the national First Nations Principles of ownership, control, access and possession (OCAP) make clear the importance of free, prior, and informed consent (FPIC). I applied these principles to meet my fourth research goal, which was to engage respectfully and reciprocally with Líl̓wat people and Líl̓wat knowledge, guided by the S7ístken Líl̓wat Research Protocol (Leo et al., 2006).

In Chapter 2, I compared two methods for incorporating IK in pine mushroom species distribution modeling (SDM), using the software Maxent (S. J. Phillips et al., 2006). Through developing an SDM I also investigated which environmental variables can be most informative when predicting pine mushroom habitat. Chapter 2 generated the spatial data requested by Líl̓wat Nation. In Chapter 3, I used qualitative ethnographic methods to document 1) the significance of pine mushrooms to Líl̓wat people, and 2) how are/were pine mushrooms

managed by Líl̓wat people, as well as to 3) describe what is needed to safeguard Líl̓wat interests in pine mushrooms.

4.2. Modeling with IK

Social challenges can arise for scientists unaccustomed to collaborating with Indigenous Knowledge Holders and Indigenous institutions, but can be overcome with a commitment from researchers to take the time needed to engage in respectful and reciprocal research. Among the strategies I employed were working collaboratively with Líl̓wat Nation to set research objectives and generate meaningful research products based on community needs, and developing relationships with Líl̓wat community members during and outside of research activities, as emphasized in the S7ístken Líl̓wat Research Protocol (Leo et al., 2006). A common technical challenge of working with IK-derived data is bias, compounding the bias that arises from presence-only data, but can be addressed during model development, using, for example, a bias grid. Validation using an independent dataset would enhance understanding of model accuracy, however was not undertaken as part of this research.

The effort to find solutions to both types of challenges can be highly worthwhile when modeling species, such as pine mushrooms, whose distributions are rare due to inherent variability and elusive occurrence. I elicited IK to develop two models: 1) the “Field” model wherein IK was used to locate and record pine mushroom occurrences in the field, and 2) the “Verbal” model wherein IK was used in place of field data to approximate and locate occurrences on a map. The results demonstrated that IK can be a source of sound occurrence data, yielding models with notably better-than-random predictive power. The models I produced reported area under the curve (AUC) values of 0.920 for “Field” and 0.923 “Verbal”, which are much higher than the suitable minimum for conservation planning (0.70) (Elith et al., 2006). I found that elevation was the strongest environmental predictor variable, with most suitable habitat located near water features and up to approximately 700 meters elevation. These results are also consistent with customary Líl̓wat land use patterns, including deer hunting, and permanent and seasonal settlement, suggesting a complex relationship in which thousands of years of Líl̓wat land use have both influenced and been influenced by, the availability of pine mushrooms, among other traditional food sources. The information revealed by the models complements and is enriched

by Líl̓wat IK to produce richer insights into what constitutes suitable pine mushroom habitat in the study area within Líl̓wat territory, where suitability is a function of not only environmental conditions, but also traditional use.

4.3. Ecocultural Valuation

Data elicited from semi-structured interviews, participant observation and document analysis revealed that Líl̓wat people have a long history of stewarding pine mushrooms, evidenced by specific management and harvesting practices, and linguistic references. The results indicate that engaging in pine mushroom harvesting provides Líl̓wat with a means of strengthening ties with their territory, their family, and their ancestors, as well as serves as an act of resistance to ongoing colonial institutions. Key conditions must be met for Líl̓wat people to continue experiencing these benefits, however. These include secure tenure rights and/or rights to control access to productive pine mushroom habitat, as well as intergenerational transmission of the traditional knowledge required for sustainable and safe harvesting practices. Where administrative access may be met, in part, through securing more forestry tenure, more secure, long-term access requires that Líl̓wat Nation has greater authority over land management policies throughout their territory, including the authority to make trade-offs between timber and non-timber values. Greater authority to prioritize forest management for non-timber values, including protecting the integrity of intact forests, would also provide Líl̓wat Nation with more secure environmental access to productive pine mushroom habitat. Intact forests are more resilient in buffering the effects of climate change, such as drought, which has already been observed by Líl̓wat people in relation to pine mushroom productivity. Finally, sufficient habitat is necessary not only to yield pine mushrooms, but also to develop the place-based Líl̓wat knowledge of how to locate and harvest mushrooms in ways that support future growth and protect the safety of Líl̓wat community members. The historic disposession of Líl̓wat lands, coupled with the residential school system, and environmental degradation have compounded to estrange many Líl̓wat people from their territory and land-based cultural practices. Cognitive access can be secured through cultural revitalization, but requires both the rights to determine the future of their territory, as well as ecological integrity capable of supporting cultural use over the long term.

4.4. Closing Thoughts

This study extrapolated to a landscape scale what Líl̓wat people already knew at a fine scale about pine mushroom habitat, and documented pine mushroom community-use areas in a spatial layer that can be used by Líl̓wat Nation in future GIS overlays. I produced both research outputs based on community-defined objectives. Doing so not only benefitted Líl̓wat Nation by prioritizing their interests, it created a foundation for collaboration and trust—without which I would not have gained access to Líl̓wat knowledge, nor the holistic analysis it afforded.

Mapping pine mushroom habitat and documenting Líl̓wat traditional and contemporary use assists Líl̓wat Nation to fulfill multiple resistance objectives: 1) providing further documentation of uninterrupted Líl̓wat presence in their territory, and 2) making visible those interstitial map spaces that would otherwise be overlooked. While not all Líl̓wat people rely on pine mushrooms for subsistence, or hold Indigenous knowledge of where they grow and how they should be managed, mapping pine mushroom habitat creates a placeholder for those lands to remain available as places for Líl̓wat people to choose to live and learn as their ancestors have done since “time out of mind”. Managing pine mushrooms and their related ecosystems according to Líl̓wat cultural values is a practical means of reorienting forest management practices to respect Líl̓wat Indigenous rights, as recognized by the UN Declaration on the Rights of Indigenous Peoples and affirmed in the 1911 Declaration of the Lillooet Tribe.

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Appendices

Appendix A Interview questions

1. For how long have you been harvesting pine mushrooms in your Traditional Territory?
2. Would you share with me your memories of mushroom harvesting, for example: who you went with; how you traveled; what months/seasons of the year; how long you spent harvesting?
3. Did Líl'wat7úl families have acknowledged rights to separate mushroom areas, equivalent, for example, to family-owned salmon fishing areas?
4. Is there/was there any rule(s) at the level of the community regarding mushroom harvesting?
5. For how long have the mushroom areas been in use by Líl'wat7úl?
6. Can you please indicate on this map all the places you have gone to harvest pine mushrooms in your Traditional Territory?
7. What of uses of the pine mushrooms: have there been any changes in the uses of pine mushrooms over the years?
8. Have you noticed any changes to each/any of the areas where you pick, which you believe have affected the growth of pine mushrooms? If yes, what changes, and what do you think has/have been the cause(s)?
9. Do you ever try to find new places to harvest mushrooms? If so, how do you choose those places, and/or what environmental indicators do you look for??
10. Are there places that seem like they should be good for harvesting mushrooms, but aren't? Why do you think that might be?
11. In your case, approximately what percentage of your pine mushroom harvest is for home use versus sale? If you don't mind sharing, could you please tell me approximately how much income do you earn per year from those that you sell?

Appendix B Interview and document analysis codes

1st cycle codes	2nd cycle codes	Themes
Adapting traditions	Acknowledgement	Access & authority
Asserting connections to land	Climate change mitigation	Fighting & resisting
Asserting intellectual property	Connecting to ancestors	Living as Líl̓wat
Asserting Líl̓wat sovereignty	Connecting to other people	
Asserting relevance	Cultural resurgence	
Asserting rights	Ecological integrity	
Asserting Sta:t̓yemc law	Evidence of presence	
Asserting title	Expression of history, title & rights	
Being overlooked	Health	
Creating insurance	Hedge against food & economic insecurity	
Delegitimizing Canada	Indigenous law & governance	
Documenting	Knowledge transmission	
Establishing history	K'úl'tsam̓	
Establishing meaningful indicators	Learning from nature	
1st cycle codes	**2nd cycle codes**	
Establishing permanence	Navigating the past; charting the future	

1st cycle codes	2nd cycle codes
Expressing collective voice	Practicing k'úl'tsaḿ
Fighting for freedom	Practicing nt'ákmen
Fighting for justice	Practicing nxékmen
Fighting for self-determination	Rebuilding social fabric
Fostering reciprocity	Reciprocity
Governing through stories	Reclaiming independence
Humanizing issues	Reclaiming space
Learning from animals	Remembering
Linking Sta ́ta ̓yemc and Lí ̓lwat	Resisting opression
Linking resource use to rights	Respect for nt'ákmen and nxékmen
Managing through stories	Responsibility to nature
Moving slowly	Rules of engagement
Observing nature	Sharing knowledge
Practicing nt'ákmen (our ways) and nxékmen (our laws)	Stories
Reclaiming	
Reconnecting with culture	
Reframing	

Repositioning power

Seeking compensation

Separating Líl̓wat from Sḵát̓yemc

Setting rules of engagement

Setting the record

Sharing knowledge

Subverting colonial institutions

Valuing ecosystems

Worrying about the future

Appendix C Literature reviewed during document analysis

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