A HABITAT-USE AND DIETARY ANALYSIS OF A MONOGASTRIC VERSUS A RUMINANT HERBIVORE, ON FORESTED RANGE

BY

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ABSTRACT

Interactions between feral horses and range cattle were studied on forested range of the Chilcotin Plateau in Central British Columbia from May, 1979 to August, 1980. Research objectives included collecting information on habitat-use, distribution and diet selection for horses and cattle, and habitat-use and distribution data only, for moose. Based on approximately equal, average defecation rates, the relative abundance of each species in the 200 km^2 study area, was estimated to be 89.7 percent cattle, 7.4 percent horses and 2.9 percent moose. The equine study population was organized into five harem groups, each composed of a single stallion with adult mares and immature animals of both sexes, ranging in group size from 5 to 14. Surplus adult males formed four bachelor groups of between one and four animals.

A detailed analysis of all habitat types was not practicable nor considered essential in this study. The breakdown of the study area into seven general habitat types was based on macrovegetation associations which seemed to reflect broad habitat-use patterns and included open forest, semi-open forest, closed forest, meadow, shrub carr, interface zone and 'other' (e.g. roads). A botanical profile of the area, and concomitant plant collection, was done over the two summers of field work. Positive identification was achieved for 148 plant species, but no attempt was made to determine availability of the various species quantitatively.

Fecal epidermal analysis was carried out on fecal samples collected for horses and cattle from June through September and for horses in winter. Results indicated at least 54 different plant species were used by the two herbivores. Eleven plant species were found to consitute 80% of the cattle diets and 86% of the horse diets, indicating at least 80% of the two herbivore diets were derived from only 7.4% of the available plant species. Horses utilized fewer plant species in the winter, and while the use of grasses was reduced, sedge and shrub-use increased.

A system of random transects of between 18 to 25 km in length were used on a regular, consecutive basis to collect distribution and habitat-use data for horses, cattle and moose. Depending on the individual transects, a greater or lesser degree of spatial overlap was indicated for the three herbivores and the concentration of use in any area varied widely between species.

The designated habitat types were measured along each transect and were assumed to reflect habitat availability for the entire study area. None of the three herbivores used the habitats in proportion to habitat availability. Both horses and cattle used meadow habitat disproportionately more (though not necessarily in the same locations), and cattle also indicated a preference for interface zone, while moose used open forest, closed forest and shrub carr disproportionately more.

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of ferrying horses, gear and vehicles from Vancouver to the, at times, almost inaccessible study site.

Chapter 1: Introduction

Broadly defined, "competition occurs when a number of animals, of the same or different species, utilize common resources the supply of which is short; or if the resources are not in short supply, competition occurs when the animals seeking that resource nevertheless harm one or the other in the process" (Birch, 1957). The concept of competition remains a controversial topic as pointed out by Schoener (1982), oscillating between the extreme views of its being a rare biological phenomenon (Wiens, 1977) and a major driving force of natural selection (Diamond, 1978). 'Shortage' or limitation of a resource, is an extremely nebulous concept as pointed out by White (1978), because of the range of mechanisms which animals appear to employ to avoid direct interaction. Such 'Interaction Avoidance Mechanisms' may be behavioral, as in grazing times and diurnal cycles (Arnold, 1981; Arnold and Dudzinski, 1978; Arnold, 1964), feeding experience (Arnold, 1964; Arnold and Maller, 1977; Leuthold, 1977), food habits and adaptability (Laycock, 1978; Leuthold, 1977; Carpenter et al., 1979; Smith et al., 1979), 'specialist' vs. 'generalist' feeding strategy (Ellis and Travis, 1975; Nudds, 1980), or non-random use of habitat (Sanderson, 1966). The mechanisms may also be physical, including the herbivore-specific grazing mechanics dictated by the species' morphology (Leuthold, 1977; Arnold and Dudzinski, 1978; Moehlman, 1974), size and physical maintenance parameters (Hungate et al., 1959; Elsden et al., 1946; Jarman, 1974), and ecological aspects of animal metabolism

(Kleiber, 1961; Geist, 1974; Bell, 1971). Bell (1971) summmarized these latter in the following statement: "Small animals can tolerate diets that depart from the optimum in quantity; large animals, particularly non-ruminants, can tolerate departures in quality." Although relative food shortage can exert a profound effect on the ecology of animals, to the point of starvation, the point at which food shortage ceases to be due to the interaction between an animal and its environment, and begins to be between the animal and its associates, is extremely ambiguous.

It is important that the two components of the theory of competition be recognized, distinguished by Park (1954) as 'exploitation' and 'interference.' Exploitation refers to the relative success of two or more individuals, or species which have free access to a limited resource. Interference, is when some form of space is substituted for a resource and is the object of competition (Miller, 1969; Ayala, 1970). Interference is a more straight forward concept than exploitation, and is more easily shown to occur, as in the aggressive behavior of two species of chipmunks (Eutamias dorsalis and E. umbrinus) in Nevada (Brown, 1971). Brown's study supports the Principle of Competitive Exclusion formulated by Grinnell (1904) and Gause (1934). Exploitation, however, is much more difficult to test because of the elusiveness of 'at what point a resource becomes limiting', for as White (1978) points out 'there can be shortage without competition.' Slobodkin (1962) was inspired to rephrase the Gause Principle that species cannot coexist using too similarly the same resources, as a rule of ecological procedure rather than a verified or verifiable proposition. This is not to say the exploitive form of competition, which includes diet over-lap, does not exist, but rather that evidence indicative of its occurrence should be carefully evaluated and results not be anticipated. A review of current field-work on the subject (Birch, 1979) supports the contention of Den Boer (1980) that at least in the exploitive form, 'competitive exclusion' must be considered as only an exceptional outcome of the possible interactions between species.

Historically, it is interesting to compare the philosophy behind the ecological studies of African versus North American ungulates; the two together make up the bulk of literature on herbivore interactions. The nutritive work on ungulates in Africa and Asia has focused on selectivity and ecological separation to try to explain the apparent harmony of complex communities (Leuthold, 1977; Grimsdell and Field, 1976; Bell, 1971; Jarman, 1974; Talbot and Talbot, 1969). The work in North America has centered around the degree of diet overlap and the spatial relations among herbivores, with the basic premise that competition between species is inherent for limited range (McMahan, 1964; Hansen, 1976; Storrar et al., 1977; Willms et al., 1979). It is possible that this latter emphasis came about because the western range lands were depleted of forage, due to overstocking of domestic animals as early as 1880 (Parker, 1954), and several native ungulates were drastically reduced in numbers (e.g. Cervus elaphus nelsoni) along with their natural predators (e.g. Canis lupus, Ursus arctos) long before broad spectrum ecological studies began. Recently, however, the pendulum has begun to swing back in favor of multi-species range management (Richmond, 1980; Hudson, 1980).

At this time, no cases of exploitive competition have been proven to occur among ungulates in North America, only similarities in habitat-use and diet have been indicated. Similarity of use does not necessarily imply competition, but in regard to feral equids (Equus caballus and E. asinus) and other herbivores there has been a trend, both historically (McKnight, 1958 and 1959; Storrar et al., 1977), and in recent literature (Koehler, 1961; Willms et al., 1975; Hansen, 1976; Hansen et al., 1977) to equate 'similarity,' 'overlap' and sometimes only 'juxtaposition,' with the concept of competition.

Management decisions, including complete removal of feral equids in localized areas, have been made in the past, both in the United States (McKnight, 1958; Thomas, 1979) and in Canada (Salter and Hudson, 1978b), on the assumption that competition exists between feral horses and burros with other forms of wildlife and with livestock. However, as obvious as it may seem it must be emphasized that realistic management decisions can only be made with adequate knowledge, and knowledge of the habits and diets of feral equids in the various niches that they occupy is very scarce, particularly on forested ranges.

The broad goal of the present study was to obtain information on the interactions between horses and cattle (Bos taurus) regarding habitat-use, distribution and diet. Moose (Alces alces) were included in habitat-use and distribution data, but not in the diet analysis. Specific objectives were as follows:

1. Establish general habitat types and determine the percent availability of each type in the entire study area.

2. Determine, in relation to the way habitats were available, whether horses, cows, and moose were selecting for particular habitat types.

3. Determine whether there were differences in the choice of habitat types among horses, cows and moose.

4. Investigate whether horses, cows and moose were distributing themselves differently in space.

5. Establish what plants (i.e. variety of species) were available to the animals in the study area.

6. Determine, by fecal epidermal analysis, what plant species comprised the diets of horses and cows, and to what degree the diets were similar.

7. Determine whether the same botanical groups were being used in the same proportions by horses and by cows.

8. Compare the diets of horses for the spring, summer and fall with their winter diets.

9. Determine the broad social organization of feral horses found in the study area, and establish relative home-ranges of the groups.

Chapter 2: Materials and Methods

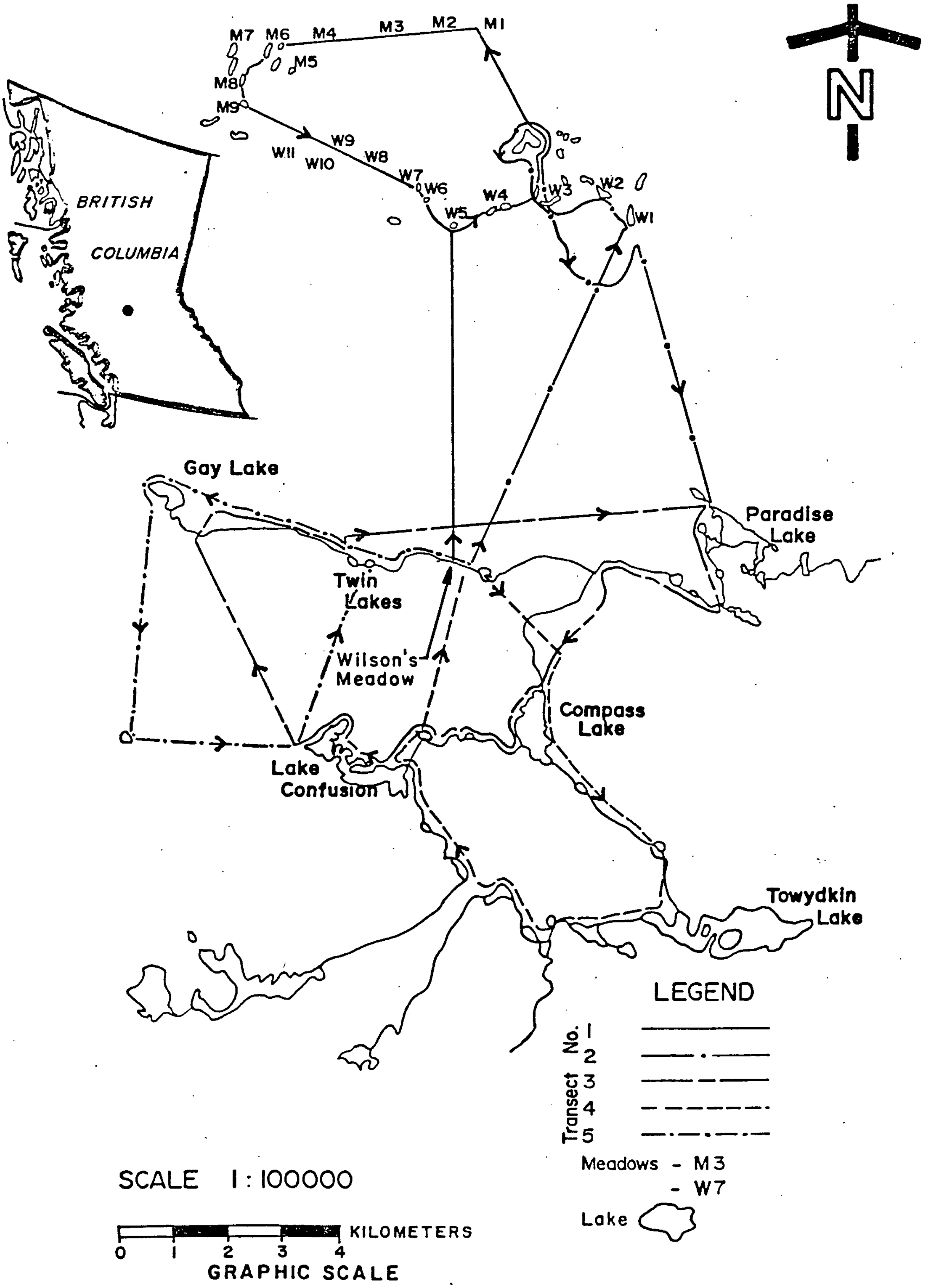
2.1 Study Area

The study began in May of 1979 and the field work was divided into three periods as follows: May 23 to October 1, 1979; March 1 to March 10, 1980; and June 1 to August 15, 1980. A total of 6 1/2 months was spent on the study site.

The study area was located between Haines Lake and Gay Lake (123° 24' W, 51° 57' N), 24.3 km S. W. of Alexis Creek, B.C., at an elevation of 1050 m asl, and covered approximately 200 km^2 (Figure 1). The area is generally flat with gently rolling terrain, covered by a forest of Douglas fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*), with localized spruce and poplar, interspersed with lakes, marshes and meadows. The topographical features are a result of combined glacial and volcanic activity. Much of the area is rather difficult to traverse because of the forest density and the widespread occurrence of boulder fields of glacial and volcanic origin. These features also affect the distribution and movements of wildlife and domestic stock.

The area is classified in the Interior Douglas Fir (IDF) Biogeoclimatic Zone (Annas and Coupè, 1979), including all areas that climax in Douglas fir on mesic sites. The IDF (b) subzone (Douglas fir-pinegrass, northern phase) is an extremely important forested subzone in terms of range productivity, and provides the majority of summer grazing for cattle in the central B.C. region (Annas and Coupè, 1979). The study area was located in the more westerly portions of the IDF(b)

Figure 1: Map of study area, showing arrangement of the five transects, ranging from 18 to 25 km, radiating from the center of the study site, "Wilson's Meadow" (discussed in sec. 2.3).


M7
M6
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M3
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W11
W10
W8
W7
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Compass
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Confusion
Towydkin
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LEGEND
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Meadows - M3
- W7
Lake
SCALE 1:100000
KILOMETERS
0 1 2 3 4
GRAPHIC SCALE

subzone.

The study area included parts of three different range allotments where cattle (Herefords predominating) ranged from June through October with a peak grazing density in July-August. A population of feral horses also used the study area divided for the most part, into distinct social groups.

2.2 Equine Study Population

A fluctuating number of domestic horses shared the study area with 65 horses identified as feral. The feral horses were organized into at least eight distinct groups, plus one individual stallion without a harem. Table 1 shows the basic composition of the groups identified.

2.3 System of Line Transects

Although aerial photographs were used during the study to establish transects, and to supply more specific information of land features than is found on topographical maps, an overall photo interpretation of the area to determine the percent of each habitat type available proved to be impractical. The region is composed of habitats which are in too tight a mosaic to distinguish realistically on black and white photographs. Such habitat types as 'Interface Zones' and those based on the precise separation of forest density, are difficult to recognize, although these areas probably have biological significance regarding animal utilization. Habitat-type separation would probably be feasible by aerial photograph interpretation if colored photographs were available for the region.

TABLE 1:

Composition and Sightings of Feral Horse Groups

Sightings	Locations	Stallion Groups	Mares	Foals, up to two years	Total*
4	3	1	8	5	14
29**	8	2	3-5	2-7	6-13
6	4	3	3	1	5
5	5	4	9	3	13
1	1	5	6	3	10
		Bachelor Groups			
4	4	6			3
2	2	7			2
5	5	8			4
6	5	9			1

*including stallion

**group most closely observed. All group changes noted over 15 months (Table 3).

A method of random transect analysis was used in the study which more accurately reflected the vegetational components available to animals. The basic method involved the development of a modified transect system in the form of five 'circuits,' all originating and returning to the central area where the study cabin was located at 'Wilson's Meadow' (Figure 1). The final layout of the transects was determined by practical considerations, including where saddlehorses could maneuver and the distance which could be covered on a daily and seasonal basis. The final five transects ranged from 18 to 25 km in length (Figure 1), and were divided into 0.5-km intervals on the ground to ensure that the rider's position on the transect would be known with reasonable accuracy while data were being collected. The accumulated distance of each habitat type along each transect was recorded, enabling the production of a composite picture of the habitat types available on each transect. In addition, each transect was ribboned with survey tape and lightly cleared of overhanging branches to facilitate riding them repeatedly and as accurately as possible. Minimal vegetation was removed to avoid encouraging animals to use the transects. This is an obvious danger when using a repeating transect system in heavily wooded terrain. There was no indication (e.g. such as fecal or hoofprint concentrations) during the two summers' field work, that the transects unduly affected the movements of animals in the area. Certainly no segment of any transect was adopted as a regular travel route.

Each transect was ridden on a regular, consecutive basis (i.e. the order of riding the transects was not changed), during which all fresh horse, cow, and moose signs within 3 m of either side of the saddlehorse were recorded on data sheets. This method worked well for these three species because signs in the form of feces, beds, and tracks are large and can be quickly and efficiently recorded from horseback in the different habitat types. Little difficulty was encountered in identifying the respective feces as has been shown to be a problem in studies of more closely related species such as elk and moose (Neff, 1968). Saddlehorse defecations were removed from the transects when they occurred. Each transect was ridden a total of 12 times, three times each in August and September, 1979; and three times each in June and July, 1980. The accumulated distance ridden for all transects was nearly 1200 km.

2.4 Botanical Profile of Study Area.

In order to establish some system of habitat classification and to carry out a diet analysis, it was necessary to have a clear idea of plant species present in the area. Subsequently, a botanical survey of all plants observed, and concomitant plant collection, were made over the two summers of field work. Positive identification was achieved for 148 plant species (Appendix 1). Due to time and manpower constraints, no attempt was made to determine availability of the various plant species quantitatively.

2.5 Establishment of Habitat Types

The breakdown of the study area into general habitat types was based on macro-vegetation associations. Although there is no doubt that micro-habitats are often important to animals, a detailed analysis of all habitat types was not practicable. In some cases, there were large variations in plant types between habitats. Consequently, this variation was used as the basis of separation. In other instances, habitat designation was based more on spatial differences, such as the spacing between the trees in stands of lodgepole. Resource Analysis Branch (R.A.B.) successional stage terminology was used in defining habitat types (Walmsley et al., 1980) on wooded sites. Habitat designation was also described in terms of relative density from visual estimations of foliage cover.

Initially, 10 habitat types were described along the transects; a model habitat site in each case being described on R.A.B. habitat description forms. "Young seral" refers to non-climax species which have not yet gone through a series of natural thinnings, and are generally less than 60 years old. The canopy is essentially of even height and there is little regeneration. "Maturing seral" is generally between 60 to 140 years of age and has gone through the first thinning stages, acquiring community structure and some regeneration. The habitat types were:

1. Young heterogenous seral: Essentially subscribing to typical young seral features except tending to be found on south-facing slopes which seems to favor the presence of some Douglas fir. These areas also tend to be in juxtaposition to maturing climax. Density estimate is

semi-open (Figure 2).

2. Young homogenous seral: More strictly conforming to typical young seral form with little to moderate ground cover. Density estimate is dense to very dense (Figure 3).

3. Maturing seral: There tend to be no 'veterans', and fallen trees tend to litter the forest floor. Usually fairly uniform seral species (i.e. lodgepole). Density estimate is semi-open (Figure 4).

4. Maturing climax: Community structure with Douglas fir dominant and lodgepole well represented. A few fire-scarred 'veteran' firs. Regeneration of both fir and lodgepole. Desity estimate is open (Figure 5).

5. Dry Meadow: Two sub-types.

   a. Open meadow - often in juxtaposition to sedge meadows (which may be low points in large open areas). Forb, grass and some sedge representation.

   b. Dry, open hillsides tending to be slightly more productive in variety of species than the flat, dry areas, with more tree and shrub cover. Both types are susceptible to overgrazing (Figure 6).

6. Wet (sedge) meadow: Low areas of water accumulation, some tending to stay wet year round. Reasonably resilient to grazing pressure. Sometimes inaccessible in very wet years. Relatively low plant species variety and

Figure 2: Young heterogenous seral habitat type

Figure 3: Young homogenous seral habitat type

Figure 4: Maturing seral habitat type

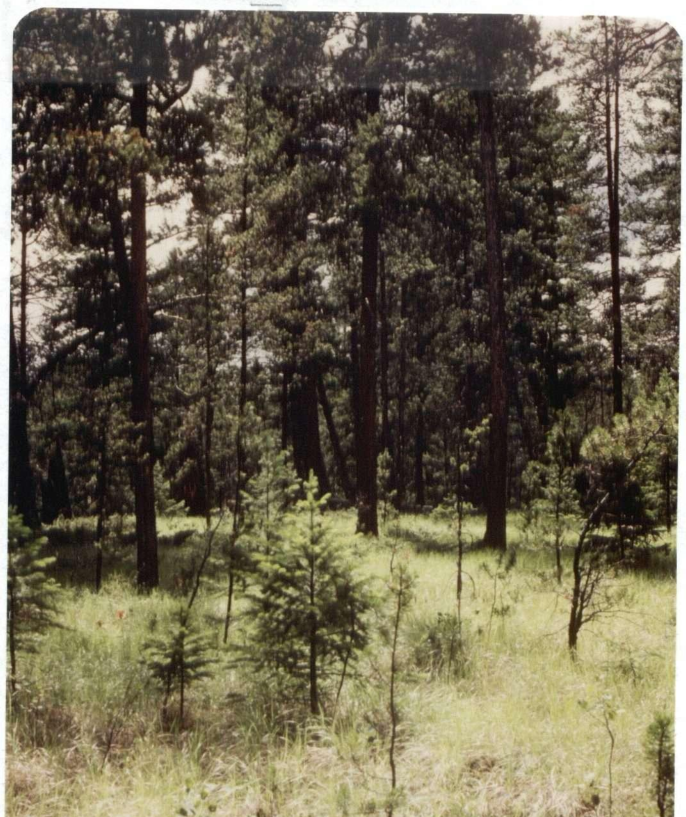


Figure 5: Maturing climax habitat type

little tree or shrub growth (Figure 7).

7. Shrub (meadow) carr: Areas frequently flooded from spring-thaw until June, with moist soil for majority of summer-fall season in an average year (Heyes, 1979) with grasses and sedges. Bog birch (Betula spp.) is dominant, with drier 'pockets' of white spruce (Picea glauca). Density estimate is open, with dense shrub cover (Figure 8).

8. Edaphic climax (spruce): Tending to be found either in erratically interspersed low lying areas (ravines); or consistently in juxtaposition with wet meadows and shrub carr areas. Provide favored bedding sites for cattle and particularly moose. Free water absent, but tendency for it to accumulate in depressions and edges of areas coincidental with shrub margins - areas hence always damp and cool (prolific mosquito-breeding grounds) - reflected in hydrophilic plant species (e.g. Sphagnum mosses). Density estimate is usually quite dense (Figure 9).

9. Logged/burned (altered) sites: Tending to be regenerative at various ages; sites are very 'cluttered' due to debris (i.e. limbs, stumps, logs) causing herb layer to be consistently disjunct. The density estimate is generally quite open (Figure 10).

10. Interface Zones: Essentially wet to dry transition zones of Spruce-Aspen-Lodgepole of varying ages. Tending to

Figure 6: Dry meadow habitat type

Figure 7: Wet meadow habitat type

Figure 8: Shrub carr habitat type

Figure 9: Edaphic climax (spruce) habitat type

be vegetatively (and often physically) complex - having high vegetative diversity in keeping with Ecotone biology. The density estimate is dense to semi-open (Figure 11).

In the final habitat analysis, the ten original designations were reduced to seven categories which seemed to reflect broad habitat-use patterns. They were:

1. Open Forest: combining maturing climax and logged/burned sites.

2. Semi-open Forest: combining maturing seral and heterogenous young seral.

3. Closed Forest: homogenous young seral.

4. Meadow: combining wet and dry (spatially difficult to separate).

5. Shrub Carr.

6. Interface Zone: combining edaphic climax and interface zones.

7. 'Other': roads, etc.

2.6 Animal Distributions

To determine whether or not the three species showed any level of association among each other, I considered their presence or absence, relative to each other, at each .5 km point along all five transects. Species were thus tabulated

Figure 10: Logged/burned (altered) habitat type

Figure 11: Interface zone habitat type

as either alone, with one other species, all together, or none present. From these values a coefficient of association, C, was calculated which can vary from +1.0 to -1.0 (Smith, 1980; 702). The significance of each coefficient was then determined by a contingency Chi Square Test.

2.7 Fecal Analysis

Fecal samples for diet estimates were collected only for horses and cows during the two summers' field work. One month's sample for each species always consisted of eight teaspoons of material, each one taken from eight individual, fresh dung piles, not always on the same site. The opportunistic approach of collecting fecal material, whenever and wherever found, was adopted because of the unpredictability of encountering horses. It was determined by experience that eight individual fecal piles was the upper limit of what could be consistently found for both species within the space of 1 to 2 days. Between 7 and 13 collections of fecal material for both species were made throughout each month from June through September, to ameliorate the possible effect of concentrations of plant types due to vegetative 'growth spurts.' The fecal material, immersed in 90% alcohol, was stored in air-tight jars, and the date of collection and all pertinent information recorded. Samples for analysis, chosen from the total monthly collections, were evenly distributed with respect to time.

The fecal samples were sent to the Washington State University Wildlife Habitat Lab for analysis. They consisted of four of the composite samples of eight individuals each, for both horses and cows, for June, July, August and September - denoted, for example, for cows in June as J-C_1; J-C_2, etc. (Appendix II). In addition, during the winter of 1979-80, ten days were spent at the study site collecting horse feces only. Samples were collected either fresh or frozen on top of the snow, representing random collection throughout the study site of one teaspoon each from 96 individual dung piles. These individual samples were all composited and two samples for diet analysis taken out. Thus the winter diets represent a larger single sample over an undetermined time period. The spring/summer/fall diet analysis for horses will be collectively referred to as 'Horse-summer' to distinguish it from the 'Horse-winter' diet analysis.

For each of the 34 diet analyses, eight microscope slides were examined for plant material that could be identified, consisting of 25 fields of view per slide (alternatively referred to as 'cover points'), or a total of 200 views per diet. Because each monthly diet was determined from four diet samples, each month consists of 800 views each, for both horses and cattle. Due to economic restraints, only two winter diet samples were examined, susequently the winter diet analysis is based on a total of 400 views.

A level of 5% probability was chosen a priori for all tests of hypotheses. Specific details of the analyses used are presented in Chapter 3.

Chapter 3: RESULTS

3.1 Observations on Equine Population

For a total of 90 horse sightings, including individuals and groups, for all time spent in the field, 65 percent were considered feral, 28 percent domestic, 3 percent mixed and 4 percent unknown. Not surprisingly, sightings were biased towards meadows, with 86 percent of horses found in them, and 8 percent in interface zones, 3 percent in semi-open forest, 2 percent in closed forest, 1 percent in other, and 0 percent in open forest and shrub carr.

The home range observations were opportunistic, as a high priority was not placed on obtaining behavioral or group information, and the mapping of minimum home ranges based on a limited number of sightings is rather tenuous at best. However, it is felt that the observations do reflect approximate areas of use, relative to the entire study area, for the eight horse groups (Figure 12). The most accurate range given is for Harem group #2, based on 29 sightings, perhaps due to the coincidence of it being located centrally in the study area. In addition, changes in group composition of Harem Group #2 were also recorded (Table 2).

3.2 Animal Distributions

In addition to providing an estimate of the types and percentages of each habitat type available, the data collected from the transects fall into two major informational categories:

FIGURE 12:

Map of minimum home ranges for all observed feral horse groups, based on sightings.

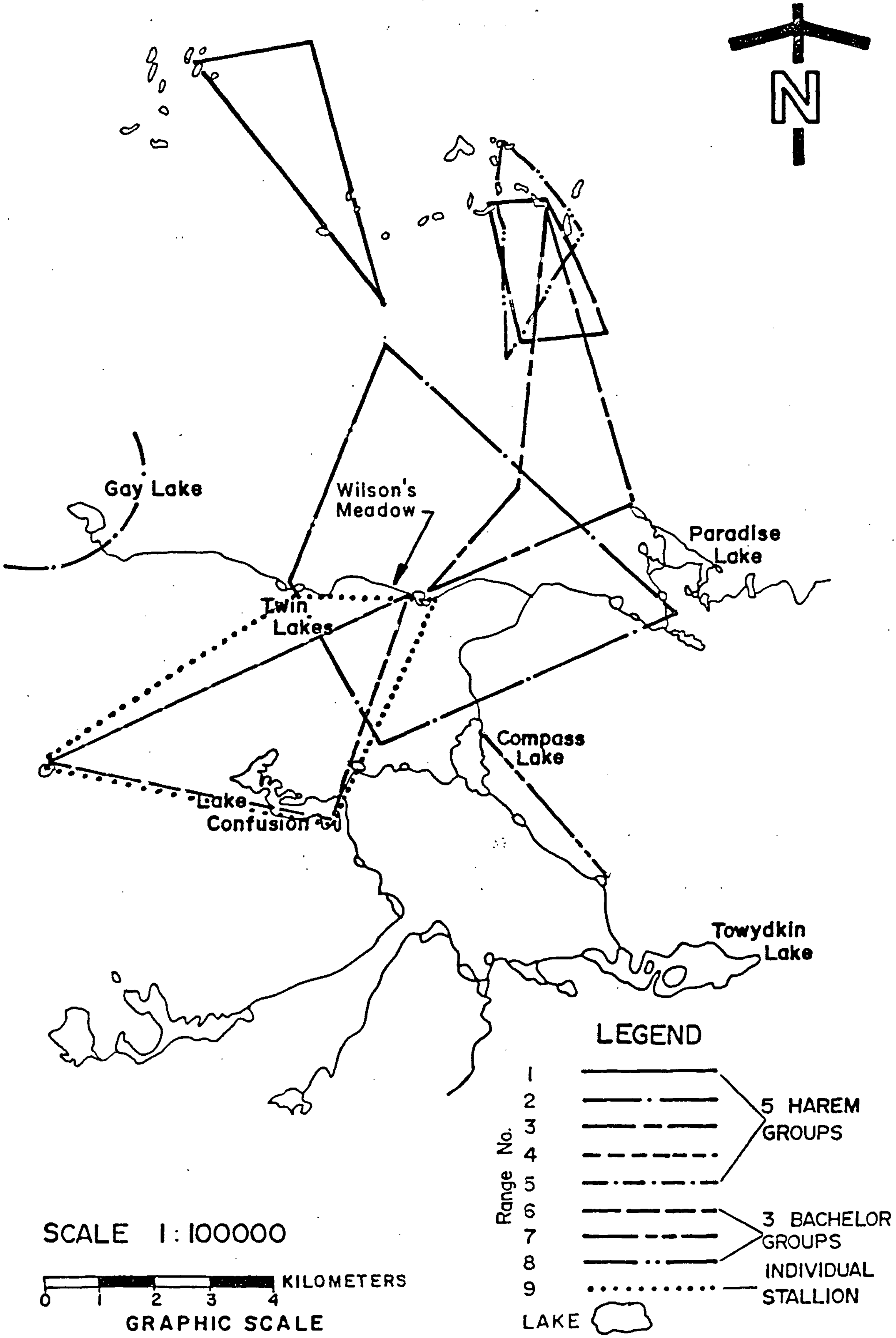

N
Gay Lake
Wilson's Meadow
Paradise Lake
Twin Lakes
Compass Lake
Lake Confusion
Towydkin Lake
LEGEND
Range No.
1
2
3
4
5
5 HAREM GROUPS
6
7
8
3 BACHELOR GROUPS
9
INDIVIDUAL STALLION
LAKE
SCALE 1:100000
0 1 2 3 4 KILOMETERS
GRAPHIC SCALE

TABLE 2:

Changes noted in Harem Group No. 2, from a total of 29 sightings in the period from May 24, 1979 to August 1, 1980, showing additions and losses to the band.

Date of Sighting	Original Composition	Additions	Losses
May 24, 1979	Chestnut Stallion, about 13 yrs. Heavy black mare, about 12 yrs. - wearing old leather collar. Parti-colored male yearling belonging to black mare. 2 (wild) identical brown mares, about 3-5 yrs. 1 br. female yearling, belonging to one of br. mares		
June 14, 1979		Br. male foal born to one of brown mares.	
June 24, 1979		Br. female foal born to other br. mare.	
Aug. 10, 1979			Br. male 2 mo. old foal lost from group for at least 8 hours. Later found reunited.
March 7, 1980		Red male foal born to black mare after mid-August, 1979.	1 brown mare & male foal of previous June

continued...

Table 2 continued...

Date of Sighting	Original Composition	Additions	Losses
March 7, 1980 (cont.)		New chestnut mare. New bay mare.	
June 3, 1980	<u>Final composition</u>.	Br. foal born to br. yearling of 1979. New Roan mare.	Parti-colored male. 2 New mares seen in March.
July 31, 1980	Chestnut Stallion. Bl. mare & red foal of Aug. 1979. 1 br. mare with new foal and yearling female of June, 1979. 1 (2-3 yr. old) br. mare with new foal. 1 roan mare.	Br. foal born to remaining original br. mare - with yearling female.	

1. Relative use of each habitat type by cattle, horses and moose (section 3.3), and
2. Distribution by each animal species in relation to the entire study area (i.e. all habitats available).

The latter was achieved by graphing the percent fecal material in relation to the distance along the transects every 0.5 km, to give an idea of the spatial separation between the species. This approach is important in clarifying the levels of interaction. Although cows and horses both may use meadows as a habitat type in excess of availability, if they did not use the same individual meadows, then the levels of interaction would be markedly reduced.

Depending on the individual transects, a greater or lesser degree of spatial overlap was indicated and the concentration of use in any area varied widely between the three species. The distribution of horses, cows and moose are shown in Figure 13.

The frequencies with which the three species were seen alone, with one other species, or all together, and when none were present, at each 0.5 km interval along the five transects is shown in Table 3. Calculations of the coefficients of association between each paired combination of the three species, together with the Chi Square values showed the following: 1) horses and cows were associated with each other more than expected by chance (C_{hc}=0.07; X^2=4.4, df = 1); 2) horses and moose were found together as often as one would expect by chance alone (C_{hm}=0.03; X^2=0.33, df =1); and 3) moose and

FIGURE 13:

Transects I through V, showing frequency distributions of fecal droppings for horses, cattle and moose at 1 Km intervals along each transect for the June, July, August and September period.

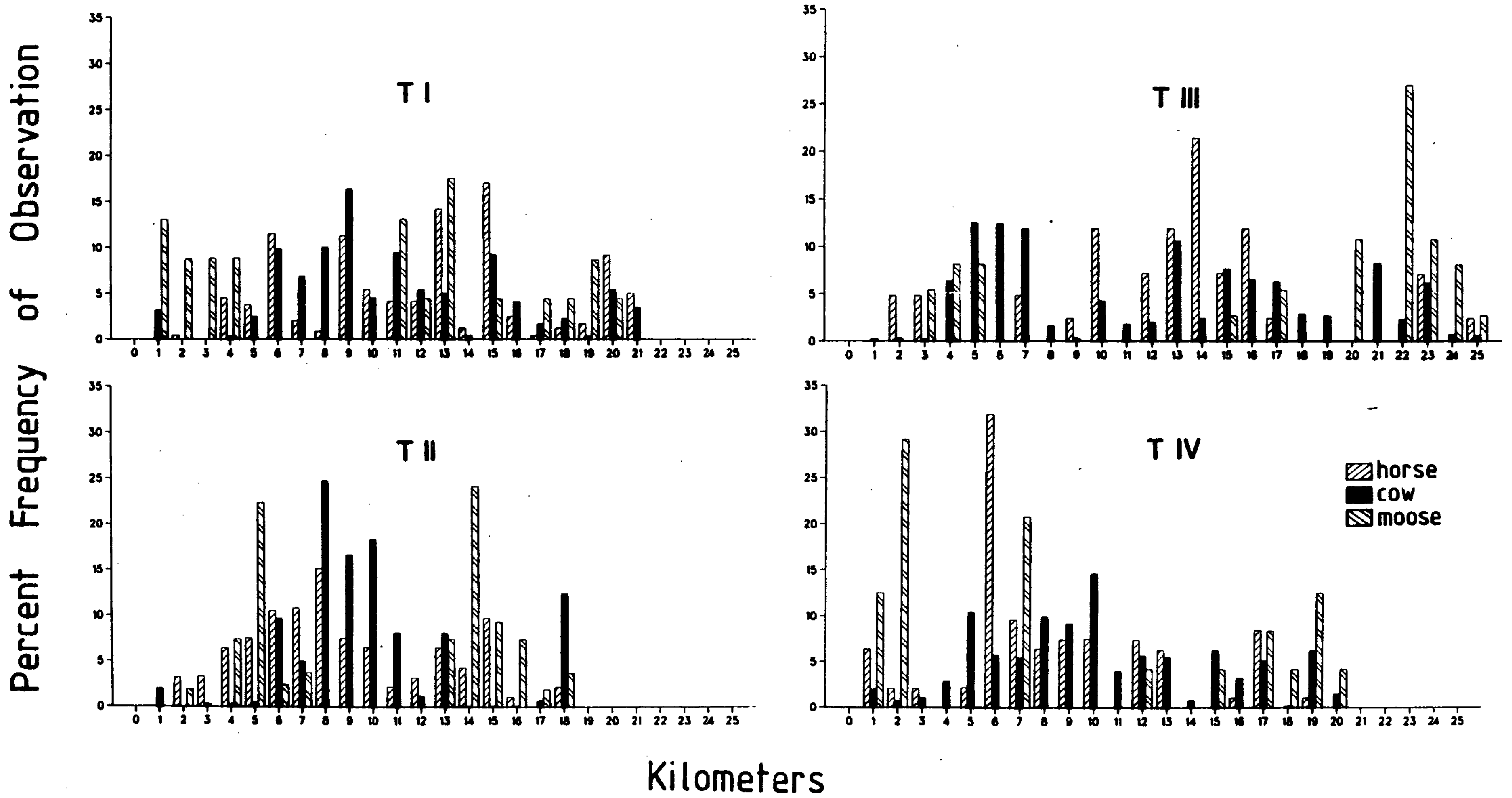

T I
T II
T III
T IV
horse
cow
moose
Percent Frequency of Observation
Kilometers

Table 3: Coefficient of Association for horses, Cattle and moose

Frequencies with which each species (C = cows; M = moose; H = horses) were seen alone, two together, all together, or none, at each 0.5 km interval on all five transects combined. Frequencies were obtained on a presence or absence basis only; actual number of fecal piles per 0.5 km interval were ignored.

Total # 0.5 km intervals	C	H	M	HC	HM	MC	HCM	None
201	55	4	14	64	8	17	33	6

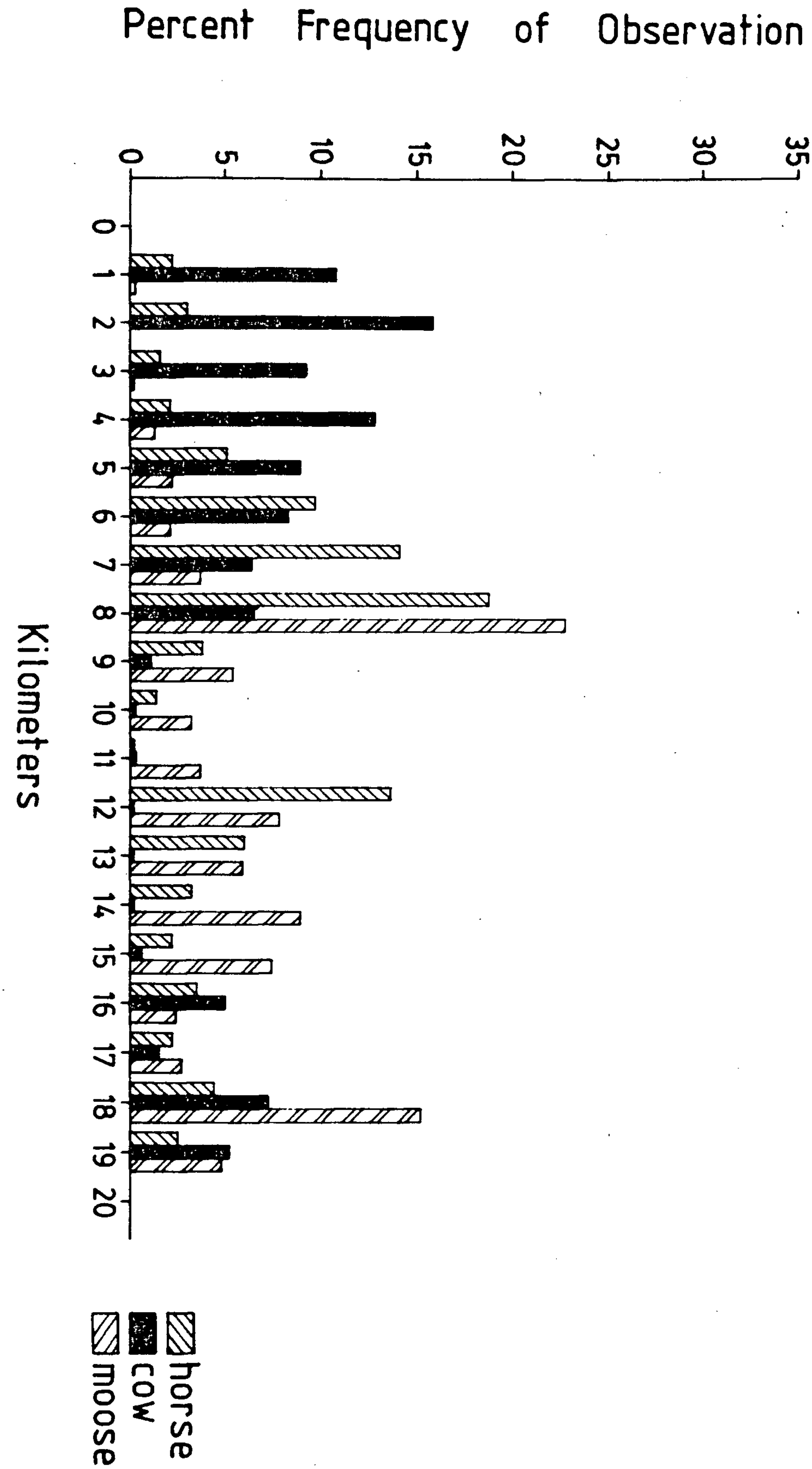
cows are found together less frequently than expected (C_{mc}=-0.51; X^2=17.81, df = 1).

To estimate the relative abundance of the three species I used the number of individual fecal piles recorded along the transects with the available data that indicate horses, cattle, and moose all have an average defecation rate of 15 to 16 eliminations per 24 hour period (moose: Franzman et al., 1976; Miquelle, 1983; cows: Hafez, 1969; horses: pers. obs.). From these data the relative proportions were 89.7 percent cattle, 7.4 percent horses and 2.9 percent moose (Table 8).

In order to compare the 'long-term' use of the area for the three species with the data collected in this study, one Transect (V) was used as a 'control.' Normally only fresh indications of animal use, estimated to be less than six days old, were recorded. However, before data collection began, Transect V was investigated in detail. The total 18.5 km was scrutinized on foot and all fecal material and other animal signs recorded within 4 m each side of the center line. The material could represent at least five years accumulation. When these 'long-term' data were graphed and compared with the graph for 'fresh' material collected over two summers on T-V, the two graphs (ignoring scale) appeared to be extremely similar (Figures 13 and 14). A Paired 't' test (Sokal and Rohlf, 1969: 205), with Arcsin Transformation (Appendix III) was run on the three sets of data, i.e. comparing 'old' and 'fresh' for each of the three species. Results showed the graphs to be different, being just into the significant range

FIGURE 14:

Transect V, showing frequency distributions of accumulated fecal droppings for horses, cattle and moose prior to regular data collection for the study.


Percent Frequency of Observation
0
5
10
15
20
25
30
35
Kilometers
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
horse
cow
moose

for all three sets of data: cows vs. cows ($t = 2.35$, 36 d.f.), horses vs. horses ($t = 2.51$) and moose vs. moose ($t = 2.68$) (Appendix III).

3.3 Habitat Use

The percent of each habitat type along each transect, based on the total distance for all transects, is shown in Table 4. A k-Independent Chi Square Test showed that a significant difference ($X^2 = 18{,}020.7$, d.f. = 24) exists among the transects in regard to the relative amount of each habitat type they contained (Table 4).

The numbers of plant species found in each habitat varied considerably between habitats. The maximum number of species (58) was found in dry meadow habitat, and the minimum number (26) was found in young homogenous seral habitat.

The percent of each habitat type measured on each transect obtained by direct measurement along the entire length of each transect, provides an estimate of habitat availability for the entire study area when combined for all five transects (Tables 4 and 5). None of the three herbivores used the habitats in proportion to habitat availability (Table 5). Both horses and cattle used meadow habitat disproportionately more, and cattle also indicated a preference for interface zone, while moose used open forest, closed forest and shrub carr disproportionately more. These differences in habitat selection between the three species were significant (Table 6), indicating species specific selection for the available habitats.

TABLE 4:

The percent* distribution of habitat type along the five transects. Numbers in parentheses are actual meters of transect covered by each habitat type, on each transect.

Transect	Open F**	Semi-Open F	Closed F	Meadow	Shrub carr	Inter-face zone	Other
I	2.3 (2280)	8.9 (8880)	3.1 (3060)	5.7 (5730)	0.0 (0.0)	0.2 (150)	0.2 (240)
II	0.7 (720)	8.0 (7980)	3.9 (3870)	3.9 (3930)	0.0 (0.0)	1.0 (1020)	0.0 (0.0)
III	4.0 (4020)	6.9 (6870)	3.3 (3330)	7.3 (7260)	0.8 (750)	1.5 (1530)	1.1 (1050)
IV	1.8 (1740)	6.0 (6000)	1.2 (1170)	6.7 (6660)	0.3 (300)	2.4 (2430)	0.4 (420)
V	5.7 (5730)	3.6 (3600)	2.2 (2220)	4.4 (4410)	1.56 (1560)	0.6 (570)	0.2 (210)

*Based on total distance for all transects (i.e. 99,690m)

**F = Forest

TABLE 5:

Habitat use versus percent Habitat Availability

1. Total fecal counts per habitat type for horses, cows and moose for all transects.

2. Chi square results for habitat use versus habitat availability for all transects for the individual species, horses, cows and moose.

3. Population estimates based on equal average defecation rates for all three species.

Habitat Type	Open F	Semi-Open F	Closed F	Meadow	Shrub carr	Inter-face zone	Other		X^2 6 d.f.	Relative Population Estimates
% Available	14.5	33.4	13.7	28.1	2.6	5.7	1.9	100%		
Horses Total	28	100	32	331	7	15	2	515	336.7*	7.4%
Horses %	5.4	19.4	6.4	64.2	1.4	2.9	0.4			
Cows Total	289	551	96	4739	103	392	46	6216	7402.8*	89.7%
Cows %	4.6	8.9	1.5	76.2	1.7	6.3	0.7			

continued...

Table 5 (cont.)

Habitat Type	Open F	Semi-Open F	Closed F	Meadow	Shrub carr	Inter-face zone	Other		X^2	Relative Population Estimates
% Available	14.5	33.4	13.7	28.1	2.6	5.7	1.9	100%	6 d.f.	
Moose Total	31	37	84	31	13	4	0.0	200	161.9*	2.9%
Moose %	15.5	18.5	42.0	15.5	6.5	2	0.0			
Total fecal count: 6931										

TABLE 6

k-Independent Chi Square Test for comparing Habitat Use Between Species, showing significant differences in use patterns for all three species.

k=7 / r=2 Habitat %	Open F. 14.5	S-Open F. 33.4	Cl. F. 13.7	Meadow 28.1	Shrub C. 2.6	I.Z. 5.7	Other 1.9	Fecal Count Totals	X_2 d.f.=6
Cow	289 4.6%	551 8.9%	96 1.5%	4739 76.2%	103 1.7%	392 6.3%	46 .7%	6216	129.0*
Horse	28 5.4%	100 19.4%	32 6.4%	331 64.2%	7 1.4%	15 2.9%	2 .4%	515	
Total:	317	651	128	5070	110	407	48	6731	
Cow	289	551	96	4739	103	392	46	6216	1327.71*
Moose	31 15.5%	37 18.5%	84 42.0%	31 15.5%	13 6.5%	4 2%	-	200	
Total:	320	588	180	4770	116	396	46	6416	

continued...

Table 6 (cont)

Habitat %	Open F. 14.5	S-Open F. 33.4	Cl. F. 13.7	Meadow 28.1	Shrub C. 2.6	I.Z. 5.7	Other 1.9	Fecal Count Totals	χ^2 d.f. = 6
Horse	28	100	32	331	7	15	2	515	216.1*
Moose	31	37	84	31	13	4	-	200	
Total:	59	137	116	362	20	19	2	715	

3.4 Diet Analysis

From the four composite fecal samples collected each month for both cows and horses-summer, and from the two samples for horses-winter, average values were determined for the presence of the various plant species in the diet each month (Table 7). The results of the monthly fecal analyses show that at least 54 different plant species were used by the two herbivores (Table 7). Using an arbitrarily chosen minimum value of 80 percent of the total diet, 11 plant species were found to constitute 80% of the cattle's and 86 percent of the horses diets (Table 8). As a total of at least 148 plant species were identified on the study area (Appendix I), this indicates that at least 80 percent of the two herbivores' diets were composed of 7.4 percent of the available species, thus indicating a relatively high degree of selectivity for plant species. It should be noted that these were the same 11 species for both herbivores, although the proportions in which they were used differed between the two herbivores and among months (Table 8).

An Analysis of Variance with Arcsin Transformation (Table 8) showed that the average consumption (i.e. concentration of use) by both horses and cattle varied significantly from month to month for the following six forages: Calamagrostis rubescens, Poa juncifolia, Stipa occidentalis, Calamagrostis neglecta, Stipa comata, and Hordeum jubatum. Further, it was found that horses always used C. rubescens more than cattle, but its average use by horses peaked in August and then declined,

TABLE 7:

Horse and Cattle Diets estimated from fecal samples collected in June, July, August and September. Plant species use based on percent presence in feces: averages from 4 composite fecal samples per animal species per month.

PLANT SPECIES	MONTHS (% diet)								
Grasses	June		July		August		September		Winter
	H	C	H	C	H	C	H	C	H
1. *Calamagrostis rubescens	18.55	11.25	15.83	10.08	42.08	21.18	30.0	23.63	7.0
2. *Poa juncifolia	17.75	10.6	9.05	2.83	4.0	6.88	7.63	3.53	1.65
3. *Stipa comata	7.73	4.48	6.1	4.88	1.43	5.75	1.83	4.3	3.95
4. *Hordeum jubatum	5.6	7.65	4.4	7.13	2.5	2.15	2.4	4.18	
5. *Calamagrostis neglecta	4.78	8.0	6.23	9.23	1.3	3.2	5.48	1.0	2.8
6. *Glyceria borealis	2.75	4.48	3.6	8.28	1.8	3.75	3.33	4.05	6.15
7. Stipa richardsonii	1.4	.93	1.53	.53	.38	.65		.6	
8. Agropyron sp.	1.28	.18							
9. Muhlenburgia richardsonis	1.03	.9	.83	1.3	.13	1.3	1.3	.6	
10. Oryzopsis asperifolia	1.0	.48	1.6	.83	.85	1.5	.4	2.08	
11. *Stipa occidentalis	.8	1.33	6.1	6.55	6.53	4.83	5.95	4.88	5.0
12. Poa interior	.3								
13. Alopecurus aequalis	.23								
14. Agrostis sp.	.13								
15. Spartina gracilis	.08	.68	.95	.25			.13	.28	
16. Beckmannia sp.	.08		.2			.18	.35	.65	
17. Unidentified grasses			.3		1.08		1.43	.5	8.15
TOTAL GRASSES	63.59	50.96	56.7	52.6	62.08	51.37	60.23	50.28	34.7
	64%	51%	57%	53%	62%	51%	60%	50%	35%
Rushes/Sedges									
18. *Juncus balticus	10.6	5.15	4.25	2.45	6.2	4.88	4.25	5.23	17.15
19. *Carex aquatilis	9.1	11.73	15.35	19.95	9.63	11.28	8.78	21.25	12.35
20. *Carex rostata	7.7	9.5	7.13	9.15	9.23	6.18	10.38	5.38	16.15
21. Carex atheroides	4.3	3.58	2.1	1.6	2.7	2.18	.4	.35	
22. *Carex concinoides	2.18	7.1	3.13	2.33	5.23	4.45	5.0	3.83	1.15

continued...

PLANT SPECIES	MONTHS (% diet)								
Grasses	June		July		August		September		Winter
	H	C	H	C	H	C	H	C	H
23. Eleocharis sp.	.25		7.48		1.88	1.78	1.48	.15	.95
24. Unidentified rushes/sedges	1.3	5.73	.95	6.03			.23		
TOTAL RUSHES/SEDGES	35.43	42.79	40.39	41.5	34.87	30.75	30.52	36.19	47.75
	35%	43%	40%	42%	35%	31%	31%	36%	48%

*Dominant 11 forages:

Other (Forbs; Shrubs; Trees)

25. Astragalus miser	.08	.38	.15	.38	1.6	.35	1.63	2.58	
26. Pinus contorta						.45	.55	.73	4.4
27. Rosa acicularis		.08	.58	.88		1.38	.15	.6	3.2
28. Picea sitchensis									1.95
29. 'Fern'							.3		1.25
30. Artemesia frigida			.25						1.0
31. Arctostaphylos uva-ursi				.4	.15	.4	.15	.33	1.0
32. Potentilla hippiana	.2	1.48	.25	.98		.98	.68	.5	
33. Shepherdia canadensis						1.65	.18	.98	
34. Vicia sp.						.63	.2	1.8	
35. Achillea millefolium	.1	.68	.35	.58	.35	.93	.18	1.43	
36. Salix spp.				.28		.73		1.13	.5
37. Sisyrinchium angustifolium	.3	.18				.98		.3	
38. Geum triflorum	.13	.33		.18		.8	.25		
39. Hippuris vulgaris	.08	.43							
40. Aster conspicuous	.08	.2	.03	.23		.13			

continued...

PLANT SPECIES		MONTHS (% diet)								
Grasses		June		July		August		September		Winter
		H	C	H	C	H	C	H	C	H
41.	Taraxacum officinale	.05	.08	.13	.13		.43	.23	.33	
42.	Fragaria virginiana		.45	.38	.25		.63		.75	
43.	Spiraea betulifolia					.08	.68		.23	
44.	Antennaria parvifolia		.1		.3	.08				.5
45.	Antennaria sp.						.18			
46.	Eriogonum sp.							.58		
47.	Sedum lanceolatum		.08		.2			.15		
48.	Juniperus sp.							.15		
49.	Betula glandulosa				.05		.08	.1		.8
50.	Arnica cordifolia		.28		.25			.08	.38	
51.	Solidago spathulata		.38				.13			
52.	Viola adunca		.23						.55	
53.	Cerastium arvense		.15						.38	
54.	Heuchera cylindrica		.08							
55.	Penstemon procerus		.08		.13					
56.	'mosses'				.48		.23			
57.	Thalictrum sp.						.28			
58.	Unidentified Forbs		.13	.9	.38	.98	5.43	2.18	.63	
59.	Unidentified Shrubs							1.68		2.8
TOTAL FORBS; SHRUBS; TREES		1.02	5.8	3.02	6.08	3.24	17.5	9.17	13.88	17.4
		1%	6%	3%	6%	3%	18%	9%	14%	17%

whereas cattle use of *C. rubescens* increased steadily over the summer and peaked in September. There was also a significant difference in pattern of use by horses and cattle for the plant species *Carex aquatilis*, *Poa juncifolia*, *Juncus balticus*, *Hordeum jubatum*, and *Glyceria borealis*. Finally, in only three species, *Poa juncifolia*, *Juncus balticus* and *Stipa comata*, was the difference in use between horses and cattle found to be significantly dependent on a particular month (Table 8). It should be noted that for both *C. rubescens* or, *C. aquatilis*, month was not important in an interaction context, because horses always ate more of the former than cattle, and less of the latter.

Considering the consistently high proportion of the 11 forages in the diets of both horses and cows, the total number of plant species actually eaten by the two herbivore species was considered in relation to how many plant species were available to them. Of 88 forbs (Appendix I) identified in the study area horses utilized approximatly 16, and cattle 20 (Table 7). Reduced dependence on forbs was recorded in winter and June horse diets. The portion of forbs in horse diets was as follows: Winter = 2.75%, June = 1.02%, July = 4.69%, August = 3.01%, and September = 7.53%. Of 43 species of grasses and sedges identified (Appendix I), horses utilized 22 and cattle only 19 (Table 7).

A factor further indicative of selectivity is found in the use of the sedges *Carex aquatilis* and *C. rostata*. Together they formed a significant portion of the diet of horses ($\overline{X}$ = 19%) and cattle ($\overline{X}$ = 24%), but were found only in sedge

TABLE 8

Average use per month of the 11 forages composing at least 80% of the diets of both horses and cows, with an analysis of variance (using transformed data) comparing the 11 plant species for utilization per month, between species and on an interaction basis:

Plant Species		June	July	August	September	$\overline{X}^a$	F_{Month}	$F_{Species}$	$F_{Interaction}$
Calamagrostis rubescens	H	18.6 ± 5.7	15.8 ± 5.5	42.1 ± 5.9	30.0 ± 19.2	26.6 ± 15.9	6.44*	8.11*	1.12
	C	11.3 ± 3.2	10.2 ± 1.4	21.2 ± 8.3	23.6 ± 5.3	16.5 ± 7.70			
Carex aquatilis	H	9.1 ± 2.3	15.4 ± 8.0	9.6 ± 7.1	8.8 ± 1.5	10.7 ± 5.7	2.61	5.82*	1.25
	C	11.7 ± 3.7	20.0 ± 2.8	11.3 ± 6.4	21.3 ± 11.4	16.1 ± 7.8			
Poa juncifolia	H	17.8 ± 3.9	9.1 ± 4.9	4.0 ± 2.3	7.6 ± 1.1	9.6 ± 6.0	16.2*	12.1*	4.54*
	C	10.6 ± 2.5	2.8 ± 1.9	6.9 ± 3.6	3.5 ± 2.2	5.9 ± 4.0			
Carex rostata	H	7.7 ± 2.4	7.1 ± 2.3	9.2 ± 2.6	10.4 ± 4.2	8.6 ± 3.0	.108	.80	2.23
	C	9.5 ± 2.2	9.2 ± 5.3	6.2 ± 3.2	5.4 ± 3.3	7.6 ± 3.8			
Juncus balticus	H	10.6 ± 4.7	4.3 ± 2.9	6.2 ± 1.2	4.3 ± 2.1	6.4 ± 2.9	1.88	7.88*	3.63*
	C	5.2 ± 1.9	2.5 ± 1.4	4.9 ± 2.6	5.2 ± 1.5	5.2 ± 1.9			

continued...

Table 8 (cont)

Plant Species		June	July	August	September	$\overline{x}^a$	F_{Month}	$F_{Species}$	$F_{Interaction}$
Stipa occidentalis	H	0.8 ± 1.1	6.1 ± 4.6	6.5 ± 2.9	6.0 ± 2.8	4.8 ± 3.7	6.15*	.1	.53
	C	1.3 ± 1.5	6.6 ± 2.2	4.8 ± 2.3	4.9 ± 1.7	4.5 ± 2.5			
Calamagrostis neglecta	H	4.8 ± 4.8	6.2 ± 3.3	1.3 ± .6	5.5 ± 4.5	4.4 ± 3.8	5.61*	.72	2.78
	C	8.0 ± 2.5	9.2 ± 3.3	3.2 ± 1.8	1.0 ± 1.2	5.4 ± 4.1			
Stipa comata	H	7.7 ± 2.3	6.1 ± 1.7	1.4 ± 1.7	1.8 ± 1.0	4.3 ± 3.2	5.04*	.83	6.99*
	C	4.5 ± 0.5	4.9 ± 2.1	5.8 ± 3.0	4.3 ± 1.0	4.9 ± 1.8			
Carex concinoides	H	2.2 ± 1.6	3.1 ± 2.6	5.2 ± 5.4	5.0 ± 3.6	3.9 ± 3.5	.69	.21	1.56
	C	7.1 ± 4.2	2.3 ± 1.4	4.5 ± 2.6	3.8 ± 2.9	4.4 ± 3.2			
Hordeum jubatum	H	5.6 ± 2.9	4.4 ± 2.2	2.5 ± 1.6	2.4 ± 1.3	3.7 ± 2.3	9.9*	5.8*	1.04
	C	7.7 ± 1.7	7.1 ± 2.	2.2 ± 1.1	4.2 ± 1.1	5.3 ± 2.7			
Glyceria borealis	H	2.8 ± 2.0	3.6 ± 0.6	1.8 ± 0.2	3.3 ± 1.4	3.0 ± 1.7	2.91	7.04*	1.17
	C	4.5 ± 2.3	8.3 ± 1.7	3.8 ± 3.3	4.1 ± 1.4	4.9 ± 3.2			

[a]$\overline{X}$ = Overall mean for 4 months.

meadows which represent approximately 15% of the total area, and were in scattered locations. Other plant species which formed a dominant portion of the diets of both horses and cattle were found only in dry meadows (i.e. Stipa comata, S. occidentalis), or in sedge meadows only (i.e. C. neglecta, C. atheroides, and Glyceria borealis) (Appendix IV). Although a disproportionately high use of meadow habitat was indicated for both horses and cattle (Table 5), a small number of the total plant species available in wet and dry meadows actually formed a dominant portion of the diets of either animal species (Appendix IV, Table 7).

The presence of Eleocharis sp. in the diets, positively identified by the W.S.U. laboratory, appears to be the most outstanding example indicative of selectivity. Based on the percent occurrence in horse diets, it was a reasonably significant forage plant ($\overline{X}_{summer}$= 2.77%. Table 7). However, it was never actually identified on the study site and it is assumed that Eleocharis sp. makes up a relatively small proportion of the vegetation cover in the study area, or is extremely localized.

The overall, average number of plant species used by horses was found to be less in winter than summer (i.e. Horse-summer $\overline{X}$ = 29; Horse-winter $\overline{X}$ = 21; Table 7). The botanical group most drastically reduced was the grasses (Table 9). In the summer horses used a maximum of 16 and a monthly average of 13 grass species, while this was decreased to seven in the winter; a reduction of almost half. It should be noted that the category of "unidentified grasses" is assumed not to be 'new' grasses, but rather 'known' grasses in an unidenti-

TABLE 9:

Grass species eaten by Horses-summer versus Horses-winter, showing order based on percent use, and the reduction of species in the winter diet.

Order	Summer grass species	(%) $\overline{X}$	Order	Winter grass species	(%) $\overline{X}$
1.	Calamagrostis rubescens	26.6	1.	Unidentified grass	8.2
2.	Poa juncifolia	9.6	2.	Calamagrostis rubescens	7.0
3.	Stipa occidentalis	4.8	3.	Glyceria borealis	6.2
4.	Calamagrostis neglecta	4.4	4.	Stipa occidentalis	5.0
5.	Stipa comata	4.3	5.	Stipa comata	4.0
6.	Hordeum jubatum	3.7	6.	Calamagrostis neglecta	2.8
7.	Glyceria borealis	3.0	7.	Poa juncifolia	1.7
	Sub-total:	56.4		Total:	34.9
8.	Oryzopsis asperifolia	1.0			
9.	Stipa richardsonii	.8			
10.	Muhlenburgia richardsonii	.8			
11.	Unidentified grass	.7			
12.	Agropyron sp.	.3			
13.	Spartina gracilis	.3			
14.	Beckmannia spp.	.2			
15.	Poa interior	.1			
16.	Alopecurus	.1			
17.	Agrostis sp.	.1			
	TOTAL:	60.8			

fiable condition (Bruce Davitt, Pers. comm., W.S.U. Wildlife Habitat Lab, 1981). The same core-group of five rushes-sedges made up the bulk of that botanical grouping for both winter and summer diets of horses (Table 10). However, the increased amount of use of these five species during the winter was notable, increasing from 33.2 percent in summer to 48.0 percent in winter of the total diet (Table 10).

There is a possibility that sedges retain a higher nutrient content in the winter than some grasses, because of the presence of green material in the center of sedge plants. A nutrient analysis carried out on sedge material collected during the winter of 1979-80, showed that a sample from whole ungrazed sedge plants had a crude protein (CP) level of 3.78 percent (dry basis), while the selected green material from the inner parts of the plants had a CP value of 6.5 percent (Figures 15 and 16; Appendix V).

An increased concentration of shrubs was noted in horse diets from spring to winter; where June = 0.0%, July = 0.58%, August = 0.23%, September = 2.96%, and winter = 14.65%. Conifer needles occurred only in September (0.55%) and in winter (6.25%) diets.

Based on the proportion of total cover counts in the fecal analysis (Section 2.6), the concentration of use was compared for the three botanical groups: grasses, rushes-sedges and 'other' (i.e. forbs, trees and shrubs) (Figure 17), using the following Z-proportional formula (Walpole, 1982: 266-74):

TABLE 10:

Rush and sedge species eaten by Horses in summer versus winter, showing increased use of sedges in the winter diet.

Order	Summer sedge species	(%) $\overline{X}$
1.	Carex aquatilis	10.7
2.	Carex rostata	8.6
3.	Juncus balticus	7.4
4.	Carex concinoides	3.9
5.	Eleocharis spp.	2.6
	<u>Sub-total</u>:	33.2
6.	Carex atheroides	2.4
7.	Unidentified Rush-sedges	.6
	<u>TOTAL</u>:	36.2

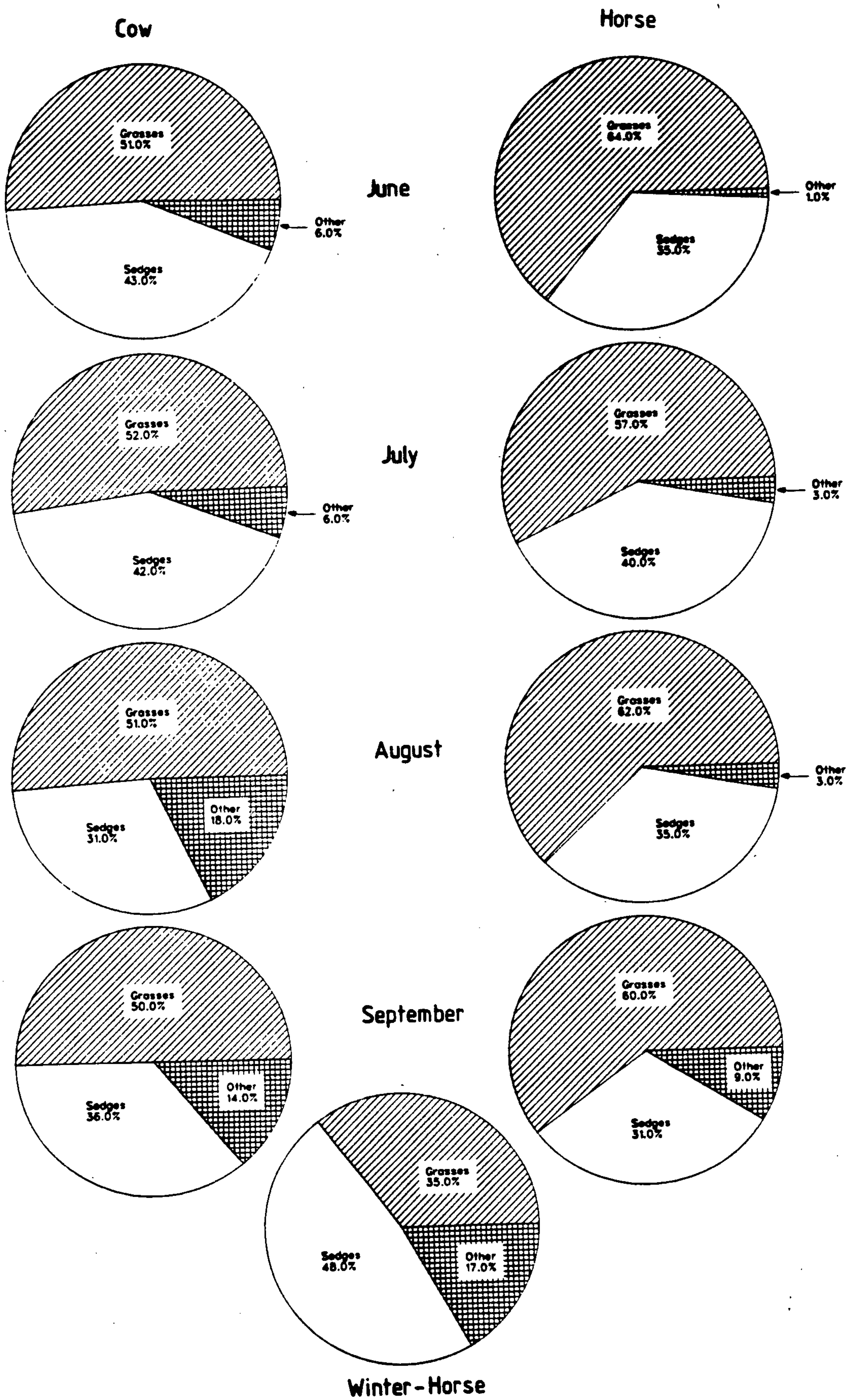
Order	Winter sedge species	(%) $\overline{X}$
1.	Juncus balticus	17.2
2.	Carex rostata	16.2
3.	Carex aquatilis	12.4
4.	Carex concinoides	1.2
5.	Eleocharis spp.	1.0
	<u>TOTAL</u>:	48.0

Figure 15: Whole ungrazed sedge plant during winter dormancy.

Figure 16: Inner part of dormant sedge plant exposed to show green shoots.

FIGURE 17:

The percent occurrence of the three major botanical groups in the diets of horses and cattle based on fecal analysis.


Cow
Horse
June
Grasses 51.0%
Sedges 43.0%
Other 6.0%
Grasses 64.0%
Sedges 35.0%
Other 1.0%
July
Grasses 52.0%
Sedges 42.0%
Other 6.0%
Grasses 57.0%
Sedges 40.0%
Other 3.0%
August
Grasses 51.0%
Sedges 31.0%
Other 18.0%
Grasses 62.0%
Sedges 35.0%
Other 3.0%
September
Grasses 50.0%
Sedges 36.0%
Other 14.0%
Grasses 60.0%
Sedges 31.0%
Other 9.0%
Grasses 35.0%
Sedges 48.0%
Other 17.0%
Winter-Horse

$$z = \frac{p_1 - p_2}{\sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}}$$

where: n_1 and n_2 = 800*
$q_1 = 1-p_1$
$q_2 = 1-p_2$

* n Horse-winter = 400

The proportional use of the three botanical groups by horses and cattle proved to be significantly different, except in the instances of grasses in July, and rushes-sedges in July and August (Table 11). The proportional use of the three groups was significantly different in horses between summer and winter diets (Table 11).

TABLE 11:

Z-Values for differences in proportional use of botanical groups on a seasonal basis:

		(Grasses)	(R-Sedges)	(Other)
CATTLE vs. HORSES	June	5.2*	3.2*	5.5*
	July	1.6	0.8	3.0*
	August	4.4*	1.7	10.0*
	September	4.0*	2.1*	3.13*
HORSES vs. HORSES	summer vs. winter	8.8	4.3	6.5

*Z greater than 1.96 = Significant

Chapter 4: Discussion

4.1 Habitat-use related to animal perception of availability

The transect system used provided a reliable estimate of the habitat availability for the entire study area. Since the IDF (b) subzone is classified as forested range, it is not surprizing that of the habitat available, 67.3 percent was forested, including habitat types open forest, semi-open forest, closed forest and interface zone. However, considered from a habitat-use perspective, it is interesting to note that only one of the three species studied (moose) is considered a true forest-dweller (Franzman, 1978). Horses are primarily adapted to dry grasslands and cattle to parkland (Groves, 1974; Camp and Smith, 1942; Walker, 1975). However both horses and cattle have become cosmopolitan in their distribution under human influences. The crux of the habitat exploitation of these three species in a forested environment revolves around the following: How adaptive are horses and cows to an essentially foreign environment? What form does their adaptation take (i.e. how similar are they)? How do horses and cows differ from moose in utilization of forest versus non-forest habitat within the environment? In general, it would seem that moose, through long association with the northern forest, and an overall distribution more closely related to the range of northern trees and shrubs than to any other factor (Coady, 1982), could be expected to exploit forested habitats more efficiently than either horses or cattle.

From this perspective, it would appear from the study results that moose are reasonably predictable in that 78 percent of all fecal counts were in forest. Horses and cows also appear somewhat predictable in being strongly attracted to open areas (meadow and shrub carr), fecal concentrations being 65.3 percent for horses and 76.9 percent for cows, although only 1.4 and 1.7 percent, respectively were found in shrub carr. However, horses appear to be more inclined to use forest habitat than cattle. Horse fecal counts indicated a 34.1 percent forest utilization and 21.3 percent for cattle. However, there is a hidden factor. Based on fecal concentrations versus habitat availability, diet results (i.e. higher use by horses of the forest species Calamagrostis rubescens); and general observations during two summers on the study site, it appears that horses use forest habitats (i.e. forest not in conjunction with open habitats) at least twice as much as cows, accounting for 31.2 percent of all horse fecal counts. Cows used forest habitat by itself only 15 percent of the time, and their fecal concentrations were otherwise found in open areas or in forest adjacent to open areas (i.e. Interface Zones). There is a distinct difference in these two forms of forested habitat use. McLean (1979) also observed that where open areas (e.g. grasslands or clearcuts) alternate with forested areas, as on my study site, there is difficulty in getting cattle to graze the forests without over-using the open areas. Such overuse of open areas was observed to occur on my study site.

Moose tended to use those habitat types (i.e. open, semi-open, closed forest and shrub carr) that horses and, particularly, cattle used the least. In addition, although the pattern of habitat use was more similar between horses and cattle than between horses or cattle versus moose, all three herbivores showed some species-specific selection for the available habitats. This variability in habitat selection produced a degree of spatial separation of the three herbivores. Supportive of this form of spatial separation were the findings, first of all, that the transects varied significantly in regard to the relative amount of each habitat type and secondly, the highest fecal counts for each herbivore species were made on different transects: the highest count for cows was on T-IV, for horses on T-I, and for moose on T-V. The greatest amount of both Meadow and Interface Zone, the habitat types that cattle appeared to favor, on the basis of use in proportion to availability, were found on T-IV. Indicative of the freedom with which horses appear to move through forest, the most contiguous forest (i.e. not including Interface Zones), was found on T-I. T-V had by far the largest amount of shrub carr; a habitat type moose used disproportionately more than it was available, and which may have attracted them to this transect.

Subsequently, the data did contribute toward an understanding of what were felt to be the three major considerations involved in habitat use, in that evidence indicated horses move about more readily in a forested environment than cattle (discussed further in Sec. 4.2); that the adaptive patterns of horses and cattle appear to be somewhat different; and that both horses and cattle differ greatly from moose in their use of habitats within the environment.

There is a potential for misinterpretation in determining the habitat types in which animals a) spend the most time, and b) are most active (e.g. travelling) (Neff, 1968). Cairns and Telfer (1980), noted that on Alberta range, bison (Bison bison), were most active in upland grasslands, but spent the most time in aspen (Populus tremuloides). They also noted that moose were most active in forest, but spent the most time, probably feeding and bedding, in shrubland. It is important to note that it is not possible to clearly differentiate between these two use-categories only on the basis of fecal counts, unless it can be demonstrated that defecations occur primarily in association with some other activity, such as occurring immediately adjacent to bedding sites. Horses, moose and cattle, on the basis of fecal counts in this study, all selected for particular habitat types in different ways, but it is not possible to say for exactly what purpose. General observations throughout the period of field work indicated cattle preferred to bed in meadow-margins, and horses in open forest. Moose had a strong affinity to closed forest, which they used three times more than would have been expected in proportion to its availability, and tended to bed in ravines with heavy spruce cover.

An attempt was made by Storrar et al. (1977) to establish a relationship between habitat selection and forage availability in feral horses. Using multivariate analysis of fecal counts, a positive response by horses to increasing pinegrass cover (i.e. forest habitat) was indicated. Results were inconclusive, however, due to lack of diet data. Salter and Hudson (1978a;

1979) felt that the availability of forage was the primary determinant for habitat selection of feral horses in southern Alberta, and that the preferred habitats of horses were meadow and grasslands. This conclusion is somewhat confusing, however, since in their study the single most significant diet component of horses was a grass species most often found in forested habitats.

In my study, horses and cattle selected most strongly for meadow habitat as shown by total fecal counts from transect data, but fecal analysis showed the most dominant forage was C. rubescens, strictly a forest species. This supports the findings of Miller et al., (1981) and other authors (Neff, 1968; Leckenby, 1968) that pellet groups do not reliably estimate the value of various plant communities to animals for forage use. Although a diet analysis was not done on moose, interpretation of habitat-use data based on food habits established by other researchers, also supported the contention that fecal counts are not directly related to forage selection. The highest fecal counts (42%) for moose were found in closed forest, the habitat type with the lowest plant species variety. Moose diets are variable, depending on availability and location, but they tend to use early successional woody browse, particularly Salix spp. (Franzman, 1978; Peek, 1974), and depend heavily on aquatic plants, if available, in the summer (Peterson, 1979; Coady, 1982), neither of which are found to any extent in closed forest habitat.

Johnson (1980) warns against making absolute statements regarding usage versus availability data, because of the inherent arbitrariness of the values. For example, arbitrariness in habitat use can be a result of how the investigator defined the habitat types, or the fact that animals have already made a selection by simply being found in a particular area, or in the case of range cattle, having been placed in a certain delimited area. Additional arbitrariness may be introduced into the equation in the case of feral horses because of their natural niche being that of open plains grazer, but showing a successful secondary adaptation to more heavily forested habitats. Only two other studies in North America have dealt with the question of habitat use by feral horses in forested environments (Salter, 1978; Storrar et al. (1977). Not enough data has been collected to be able to understand under what conditions, and why, horses select particular habitats.

With habitat availabilty, several factors must be considered such as seasonal variability, 'real' versus 'apparent' forage availability, and the ability of the habitat to meet nutritional requirements. Habitats may fluctuate wildly in nutritive quantity and quality from season to season, or from year to year, but maintenance needs of the herbivore remain relatively uniform. For example, Price (1978) showed that actual protein intake, relative to the presumed requirements in Coke's hartebeest (Alcelaphus buselaphus cokei), ranged from 148 percent in the wet season to only 17 percent in the dry season; total digestible nutrient intake varied from 196 percent to 56 percent. At least one instance of the effect of climate on habitat availability was observed during my field study. In 1979, when water levels in sedge areas, ponds and creeks were very low or dry, a large number of wet meadow areas were heavily grazed and trampled by September. In 1980, due to unseasonably high summer rainfall, and subsequent abnormally high water levels, many sedge areas were inaccessible, forcing animals to use dry meadow areas and, perhaps forest, more heavily.

Van Valen (1973 in White, 1978) wondered how to resolve the paradox of herbivores being limited by their food in a green world, where food is apparently greatly under-used. This is the paradox of 'real' versus 'apparent' forage availability, and also may apply to other features of a habitat which affect its attractiveness to animals. It is not always possible to estimate the way in which animals will perceive the usefulness of their environment, there are so many variables. For a population of domestic sheep in Australia, 80 percent of one year's diet was composed of plants comprising only 1 percent of the total forage available to the animals (Arnold and Dudzinski, 1978). Alternatively, the favored food might be coincidentally the most abundant, or animals may have learned to favor it. Animals do not necessarily utilize habitat or vegetation uniformly. In the present study, horse groups were observed to use not only the same meadows repeatedly, but also the same portions of the particular meadows. Some open areas that appeared to have good forage were not touched by cattle all summer, while similar areas were repeatedly grazed, an observation made also by Heyes (1979) in the same type of environment to the northeast of my study area. Willms et al., (1979) observed in the winter diets of deer (O.hemionus) in B.C., that although big sagebrush contributed 26 percent of the diet, only 7 percent of available plants were used, with neighboring plants being unused.

To complicate matters further, 'real' forage on offer may appear to be adequate in quantity, but not adequate in quality. Wallmo *et al*., (1977) determined for a deer winter range in Colorado that forage quantity was adequate for 14,000 deer but it could not meet protein and energy requirements; the energy being little over 50 percent of the estimated requirement. The latter nutrient being critical since the caloric need has been shown to be the primary need to which the requirements of all nutrients are linked (Blaxter, 1962). On a seasonal basis, energy shortage is a common problem to herbivores (Owen *et al*., 1978). However, protein and other nutrients may also be in short supply, compounding the problem. McLean and Tisdale (1960) found, in the Southern Interior of B.C., that the percentages of crude protein and phosphorous decreased markedly, and that crude fiber increased, in all classes of common forage from spring to fall on both grassland and forest ranges. It is likely that forage on the forest ranges probably does not meet cattle growth requirements from about mid-August onwards, but may meet maintenance requirements through October (McLean and Tisdale, 1960).

The variabilities involved in the concept of habitat availability support Johnson's (1980) contention of the arbitrariness of the array of components the investigator deems available to the animal, and seems to depend on when the investigator enters the picture. Optimal foraging theory in a patchy environment is a rather idealistic approach to resource utilization by animals, developed by Emlen (1966) and MacArthur and Pianka (1966) based on the idea that animals will forage in habitats in 'the most economical fashion,' maximizing the intake of energy and nutrients, and minimizing the time and energy required to do it. Inherent to the usefulness of this theory is the assumption that "fitness associated with an animal's foraging behavior has been maximized by natural selection" (Pyke et al., 1977). In this context, it is possible that feral horses, undergoing natural selection, and range cattle, under artificial selection, are not directly comparable in their habitat use patterns.

4.2 Distribution patterns and spatial separation

An analysis of fecal counts per habitat type along the transects showed that there was a significant difference in the choice of habitat by horses, cattle and moose indicating that each species has, to some degree, different habitat selection requirements. Evidence supported the contention previously expressed by several authors that horses are more similar to cattle in their habits than they are to moose (Storrar et al., 1977; Salter, 1978). In addition, although fecal concentrations indicated horses used forest more, and meadows less than cattle, both species appeared to use meadows considerably more than any other habitat type. The transect system used in the study allowed investigation into the distribution of animals by habitat type and also, in regard to space. The latter provided insight into the basic consideration not answered by the habitat analysis, i.e. are animals with an apparent overlap in habitat choice, necessarily using the same habitats (i.e. in the same place).

When the levels of spatial association (or conversely, the degree of separation) were evaluated, horses and cattle were seen to be associated more than would be expected by chance. Horses and moose were found to be neither interacting with, nor avoiding each other. Cattle and moose were seen to be avoiding either each other, or each other's preferred habitats. This was not a surprising result, as habitat analysis had essentially indicated the same result (i.e. moose used habitat types least used by horses and cows, and both horses and cows used meadows heavily). However, looking further, it was clearly seen on the five transect graphs that even though, as indicated, cattle and horses were more often associated with each other than with moose, the concentration of use in any given area varied widely between species.

There are several interpretations of these results. For example, the association of cattle and horses shown to occur, could reflect the fact that there are so many cattle (nearly 90 percent of the total large herbivore population) that cattle are literally 'everywhere.' Therefore, it would be almost impossible to avoid a certain amount of association, but an important unanswered question is whether the animals seek, are indifferent to, or actually try to avoid association?

If cattle outnumbered horses in any given area, it would indicate probable indifference (i.e. that horse numbers are essentially 'lost' in cattle numbers), or that the two species might even choose to be together. However, when horses are frequently found in considerably greater frequency than cattle in certain places, it would tend to indicate either an active attempt to avoid the other species, or a definite difference in the way horses and cattle choose to distribute themselves with respect to space. All five transects show numerous instances where horses are heavily concentrated in areas that cattle use only moderately, slightly, or not at all; and conversely, horses are frequently not found in areas used extensively by cows. Considering the very small numbers of horses, and the apparently strong affinity of both horses and cows for meadow habitat, which comprises only 28.1 percent of the total study area, it seems surprising to find such an unequal distribution of the two species as indicated by the graphs. For example, it does not seem likely, if movements of horses and cows are entirely random and identically motivated in terms of meadow habitat (already shown not to be so, for forest habitat), that at Kilometer 14 on T-III, which was an isolated meadow (i.e. one surrounded by extensive forest areas) the percent frequency of use indicated for horses would be 22.5 percent, and for cows, only 2.5 percent. As this example is not an isolated instance, it would appear that the distribution of horses is different from that of cattle. This difference in distribution between the two species underlines the concept that the same habitats in different locations are not necessarily equal in terms of animal use. It is possible that two areas that seem similar to the human eye, are unique in terms of animal perception. There are numerous variabilities that could account for differences in use such as traditional use patterns, distance from water, distance from similar sites, human harrassment, and many others depending on the situation. In the specific instance of the meadow at Kilometer 14 on T-III, the apparent reluctance of cattle to use forested areas could keep them from gaining access to an otherwise acceptable forage area. Due to a history of human harrassment in the area, horses may have 'learned' to use the more isolated and less accessible areas of the region. Certainly habit and experience influence an animal's perception of availability, and therefore its distribution. Weaver and Tomanek (1951) noted that cattle developed 'grazing routes' on hilly ranges, and this had a marked effect on the use of vegetation. Forested range appears to share attributes with 'hilly ranges' in this respect, as my observations indicate habitual routes (e.g. trails and inter-connecting meadows) affect vegetation use by cattle.

The lack of association shown to occur between horses or cattle and moose would seem to be attributable to several factors. First of all, the habits of moose are divergent from those of horses or cattle, and moose have been shown to have a much stronger attachment to forested habitat than either horses or cattle, which would preclude interaction to a great extent. Secondly, as shown by the transect distribution graphs, moose tend not to be quite as widespread in their distribution as horses and cattle, and thus show concentration of use in fewer areas. This could be due to the much lower population of moose (only 2.9% of the total number of all animals), and their relatively small home ranges (LeResche, 1974, cited in Coady, 1982). It is also possible that moose may actively avoid both horses and cattle.

An interest in seeing whether there were consistencies in the distributions of the three herbivores over a longer period of time led to the comparison of the long-term and short-term accumulations of fecal material on T-V. A certain amount of variation in animal distribution and habitat use patterns could be expected from year to year due to such factors as climatic variation, and reduced or expanded animal numbers. Variation could also occur from changes in 'traditional' travel routes due to death of dominant individuals or changes in leadership, factors important to social herbivores such as horses and cattle. Statistically, the two graphs of T-V, for long-term and short-term data, were shown to be different, but this difference was only just significant.

Comparison of the two graphs, however, yielded some interesting information which tended to corroborate the findings from the habitat and distribution analysis made on the five 'recent' transects. There were three notable similarities between the two graphs: The rather pronounced use of this transect by moose, the use by horses, but light use by cattle of the 'isolated' meadows distributed between Kilometers 11 and 14; and the 'absence' of cattle between Kilometers 8 and 15, which consisted essentially of solid forest with only small, scattered meadows.

The long-term versus the short-term data for T-V indicated that overall distribution patterns of the three species were different over time, while maintaining certain consistencies involving habitat preferences. It is possible that variations in habitat use are cyclic or at least partially predictable. The use of horse 'dung piles' in various parts of the study area may signal changes in distribution patterns, as some go unmarked for a period of a year or more (personal estimation), while at other sites, a long-neglected dung pile may suddenly begin to be marked and become 'active' once more. This could result from the absence of horses in an area, or some unidentified reason for lack of interest by stallions in a particular dung pile. The significance of dung piles to horses has not yet been fully established (Slade and Godfrey, 1982).

4.3 Diet choice by horses and cows

The fact that cattle and horses are both grazers (Hafez, 1964; Slade and Godfrey, 1982), would indicate a potential similarity in their diets. The limited amount of work done in North America with horses and other species (Hansen et al., 1977; Olsen and Hansen, 1977; Hansen and Clark, 1977; Salter, 1977) has shown in general that diets of feral horses are: 1) most similar to range cattle and elk, and 2) least similar to moose, deer and pronghorn (Antilocapra americana).

Diet analysis indicated that during the months from June through September, horses and cattle were exercising a fairly high degree of selectivity in their choice of forage species. For both herbivores, the same 11 forages comprised 80 percent and more of the total diet, but represented only 7.4 percent of the 148 plant species determined to be available to them. These two factors (i.e. the high degree of selectivity and 80-86% of the diets of cows and horses, respectively, being composed of the same 11 forages) indicated a large overlap in the choice of diet. However, habitat use and distribution analysis indicated diet selections made by horses and cows were not necessarily in the same location. Attempts were made to answer the critical question arising from the significant amount of overlap, which was whether a difference existed in the foraging patterns of cattle and horses? In other words, when and how were plant species utilized? Did either herbivore have any preference for a specific botanical group (e.g. grasses)?

Upon analysis, differences were found to exist in the apparent foraging patterns of horses and cattle. For example, in the use of the two major forages, Calamagrostis rubescens and Carex aquatilis, which composed an average of 37.3 percent and 32.6 percent, respectively, of the diets of horses and cattle, not only did horses always eat more C. rubescens (as much as 21% more in August), and cows consistently more C. aquatilis, but over the summer period, the pattern of use for C. rubescens was significantly different for the two herbivores. Horse use of this species peaked in August, while cattle use of it increased from June through September.

The average consumption of six of the 11 dominant forages varied significantly in their use by both horses and cattle on a monthly basis from June through September. This variation could be the result of a number of factors, such as one or more growth spurts occurring in a plant species making it more attractive to herbivores at certain seasons. Stipa occidentalis indicates this type of availability pattern in that, for both cattle and horses, use is low in June but increases in July and remains fairly steady through September. Opportunistic foraging could explain some variability if animals do not particularly seek out a plant species but eat it when they happen to find it. As indicated for C. rubescens, there were significant differences in the way horses and cattle used six of the 11 dominant forages. Glyceria borealis, for example, always was used by cattle more than by horses. In addition, whereas horses held steadily to the 2 to 3 percent level of diet content for this grass species, cattle increased their use from 4.5 percent in June to a peak in July (8.3 percent), and then came back to approximately 4 percent for August and September. Eight of the forages (not including C. rubescens, C. aquatilis and Glyceria borealis) showed flexibility in their use between the two herbivores over the four months. Horses used an average of 4.3 percent more Poa juncifolia than cattle in three out of four months, but in August, cattle used nearly 3.0 percent more than horses. Poa juncifolia was one of the three grasses, in which the difference in use between horses and cattle was found to be significantly dependent on a particular month. It is difficult to account for the variations that occur in the use of some plant species. For example, Carex rostata, decreases steadily from June through September in cattle diets, while it increases steadily in the diets of horses coinciding with a decline in overall sedge use by horses from July through September. I think that, outside of the top three or four forage choices for a particular geographical location, it is probable that the order of specific plant selection by horses and cattle would be seen to vary over a number of years if consecutive diet analyses were done. I base this contention on the evidence of the somewhat erratic and lower relative use of the other plant species in the diet, and also because most of the diet studies done to date on feral horses and range cattle have shown a similar pattern of use (i.e. heavy dependence on a very few plant species, with the percentage use of other species rapidly decreasing) (Salter, 1978; Hansen and Clark, 1977; Hansen and Reid, 1975; Hansen, 1976; Hansen _et al_., 1977). In the present study, there were large differences among the average summer use of the first choice of horses, _C. rubescens_ (26.6%), the fifth choice, _Juncus balticus_ (6.4%) and the eleventh choice, _C. neglecta_ (3.0%); similarly for cattle, the first choice being, _C. rubescens_ (16.5%), the fifth choice, _C. neglecta_ (5.4%), and the eleventh choice, _C. concinoides_ (4.4%).

The analysis of the proportionate use of botanical groups by horses and cows showed a significant difference in the monthly utilization of grasses, rush-sedges and 'other.' In summer diets horses used an average of 61 percent grasses, whereas cattle used an average of 51 percent grasses with a higher proportion of sedges, forbs and browse. Horses clearly are more oriented towards utilization of grass species than are cattle in the spring, summer and fall, particularly in light of the rather dramatic switch to sedges in the winter. This is not surprising considering the higher tolerance to fiber by horses (Janis, 1976), and the dental adaptations for a highly fibrous diet. Equid dental development exceeds that of ruminants in the combination of premolar complexity, movement forward of the main center of mastication and structural adaptations to withstand wear abrasion, including the 'infundibulum,' a deep invagination filled with cement on upper and lower incisors found only in modern equids (Lydekker, 1912; Weller, 1968; Sisson, 1953). Although, in general, fecal analysis showed that both cattle and horses were being selective as to plant species, the proportionate use of botanical groups indicates cattle were being somewhat more selective for lower fiber content material.

In winter, horses decreased the number of grass, sedge and forb species eaten. At the same time, they increased their utilization of shrub material, which is more available and holds its nutrient content better than grasses or forbs in the fall and winter (Nagy, 1969; Cook, 1956). This sort of feeding behavior would tend to offset the effects of inadequate protein and energy intake shown to occur in horses kept year-round solely on grass pasture (Owen *et al*., 1978). It is possible, but has not yet been shown to occur, that feral horses reduce their voluntary food intake during stressful periods (i.e. winter) as do some other herbivores such as deer and moose (Robbins, 1983).

The increased winter-use of rush-sedges from 33.2% in summer to 48% in winter by horses, also may have been partially attributable to availability. Rush-sedges tend to remain exposed, unlike forages in the meadow and forested areas. Snow does not appear to collect in the sedge areas despite their open aspect, or perhaps because of it (i.e. wind effects), combined with their inherent surface uneveness. The sedge areas were observed to have shallow, pooled water around the plants even on winter days when the temperature was far below freezing (pers. obs., March, 1980). Often the sedge areas offer 'pristine' grazing, as some can only be utilized in the winter, being inaccessable to anything but moose in the summer due to water depth and mud. It is possible that sedges retain a higher nutrient content during the winter than grasses or forbs. The mobile lips of horses would physically allow for the exploitation of the green material in the center of sedge plants. This material, shown to occur for both *Carex rostata* (Bernard, 1974) and *Carex aquatilis* (Gorham and Sommers, 1972), which together composed 28.5 percent of the total winter diet of horses, had a crude protein level of 6.5 percent. Weathered grasses in winter would be expected to have lower CP values. Comparative values of CP levels for some grasses in a 'weathered' condition, collected during the months of October and November, representative of species found in the study area, were as follows: *Agropyron* spp. 3.08%, *Bromus* spp. 2.8%, *Koeleria* sp. 1.89%, *Poa* spp. $3.3\%_{ave.}$, and *Stipa* spp. $3.3\%_{ave.}$ (McLean and Tisdale, 1960). In a second study (Demarchi, 1973), both *Agropyron spicatum* and *Stipa comata*, collected in late March, were found to have average CP values of 2.7 and 4.5 percent, respectively. It would appear that even with the translocation of materials to underground storage areas, such as rhizomes by sedge plants in the fall (Bernard, 1974), and the subsequent decline in nutrient content in the visible portions of the plants (McLean and Tisdale, 1960), it would be nutritionally advantageous to increase the utilization of sedge plants over grasses in the winter. Particularly so because pinegrass, by far the most important summer horse forage, although nutritionally variable on a geographical basis (McLean and Freyman, 1969), appears to be a poor winter forage. In addition to low crude protein (2.7%) and phosphorous levels, mature pinegrass has an unusually high silica content which exceeds 10 percent by October (McLean and Freyman, 1969; McLean and Tisdale, 1960). Although the diet results show a decisive increase in the use of browse and rush-sedges by horses in the winter, it is not possible to say whether it is related to the availability of these plants, to selectivity for higher nutrient content, or to both.

While horses and cattle were both on the study site from June through September, the differences in habitat-use, distribution and diet choice appeared to ameliorate the potential for interference between the two species. However, because horses depend heavily on rush-sedges in the winter, and cattle utilized them in the summer, there is a possibility that cattle summer-use could adversely effect horses. Carex aquatilis and C. rostata were the two sedges used most by horses and cattle from June through September, and together they formed a significant part (28.5%) of the winter diet of horses. However, the single most important winter forage plant for horses was actually Juncus balticus (17.2%), which sustained only moderate use by horses and cattle in the summer. This, combined with the apparently exclusive winter-accessibility of some wet meadow areas (even in very dry summers) would, again, tend to ameliorate the effect of possible interference.

By the same token, horses may undermine the value of spring range to cattle. However, based on use-differences between the two herbivores already shown to occur, and the relatively few horses, there would seem little probability of this. Salter (1978) estimated that only 5 percent of non-forested habitat on his study site in Alberta showed evidence of spring (June) grazing by horses. Forbs would be expected to be the most vulnerable to use by horses prior to the arrival of range cattle, but diet analysis indicated only a 1 percent forb use by horses in June.

The estimated diets also showed an increase in the use of conifer needles during the winter (6.25%). Salter (1978) observed a similar increase in the presence of conifer needles in the winter diets of horses, but considered the phenomenon to be accidental. I do not feel the increased use of conifer needles is accidental considering the ability of horses to expel unwanted material taken into the mouth, even when mixed with desireable items (pers. obs.). Also, some wild ruminants apparently increase their use of conifer needles during winter, which may be like mistletoe, retaining a fairly high carbohydrate content in winter (pers. comm. w. Bruce Davitt, W.S.U. Wildlife Habitat Lab, 1981). There is evidence that rumen microorganisms become adapted to the inhibitory effect on digestion of certain essential oils found in conifer needles (Wilson, 1969). Monoterpene alcohols appear to be the worst offenders in digestive inhibition (Arnold, 1981), but no reference was found regarding their effect, if any, on monogastric digestion.

It is expected that as a result of more intense mastication by horses with a dentition maximally developed for utilization of abrasive roughages, fewer forbs would be identified by fecal epidermal analysis in horses than in cattle. The major drawback of the analysis technique lies in the differential digestion of browse, forbs, sedges and grasses. There is general agreement that it is a good technique for animals whose diet is made up largely of grasses, such as the zebra (Equus burchellii) (Owaga, 1977), horses (Salter and Hudson, 1979) burros (Woodward, 1976), cattle and elk (Hansen and Reid, 1975). Grass fragments are generally quite resistant to digestion and retain enough characters for identification, unlike forbs which are much more easily and quickly digested. Work is currently being done at Washington State University to determine a differential digestion coefficient for the various animal species to which the technique is applied. In horse versus cattle diet comparisons to date, horses have not been shown to use forbs significantly. Salter (1978) states that a total level of less than 3 percent forbs were utilized each month... "species in the Potentilla-Geum groups were the only ones which appeared consistently." As pointed out by Davitt (pers. comm., 1981) the forbs that do show up, tend to be biased towards those that have hairs (like Potentilla and Geum). It is suggested that possibly the hairs tend to remain undigested and therefore can be identified. Davitt further suggests there may be a correction factor for forbs of 4 to 5 times more than are presently being identified by epidermal analysis.

Fecal analysis in this study did not necessarily indicate a weakness in the technique for identifying forbs, as there was relatively little difference between cattle and horses in their use of number of species of forbes, grasses or sedges. The results did indicate consistently higher selection for forbs in the diet by cattle for June, July, August and September. Seegmiller and Ohmart (1981) showed by fecal diet analysis, that for wild burros in Arizona forbs were the preferred foods when they were green and succulent from February to June, composing as much as 56.5 percent of the total diet. There seems no reason to assume that forbs in horse diets should be more difficult to identify than forbs in burro diets, providing the forbs are present. Conversely, there does not seem to be justification for attributing 'lack' of forbs to error in technique rather than selectivity on the part of horses and cows.

The total diets of horses and cattle represented only a fraction of the plant species comprising the botanical groups. For example, both horses and cattle used only six of the 13 rush-sedges found in the study area, ignoring some relatively widespread species found consistently in various locations such as Carex pachystachya and C. parryana. Out of 88 forb species, 16 were found to be utilized by horses and 20 by cattle. Of the 43 grass species identified, horses utilized only 22, and cows 19. Overall, the most important forage for both herbivores was pinegrass (Calamagrostis rubescens), although Carex aquatilis was utilized by cattle only slightly less. For horses, however, C. rubescens was by far the most important forage plant; more than 16 percent utilized than the next favorite C. aquatilis. Salter (1978) determined that the grass Elymus innovatus, found predominantly in forested habitats on his study area in southwestern Alberta, composed the most dominant single forage of feral horses. The major diet component of cattle in Salter's study (ignoring the 'clumped' value of sedge species) was Festuca spp., which was the second most important component in feral horse diets.

Calamagrostis rubescens is an important forage species on B.C. ranges. By far the bulk of rangelands in B.C. is on forested land, and approximately 3.2 million ha (6 million acres) of this lies in the Interior Douglas Fir Zone (IDF) (Tisdale and McLean, 1957; Stout and Brook, 1980). The IDF(b) is the largest subzone and is located almost exclusively on the Fraser Plateau (Annas and Coupè, 1979). Pinegrass may occupy up to 80 percent of the ground area in this zone (Stout et al., 1980), but varies between forested habitat types. Recent studies show that pinegrass may have two growth spurts, one in the spring and, depending partly on moisture, one in the fall. Around early July, growth is slowing down prior to summer dormancy, and that is the time it is most sensitive to grazing (Stout et al., 1980; Stout and Brook, 1980). McLean (1967) studying range where pinegrass provided 50 percent of available forage, determined that it was readily acceptable to cattle in early summer, became unpalatable by mid-August, and was again used in September (McLean, 1980). Fecal analysis in my study indicates a slightly different pattern, in that cattle showed a preference for Carex aquatilis in June and July (although pinegrass was their second choice), and essentially doubled their utilization of pinegrass for August and September. My results are also directly contradictory to the observations of Heyes (1979) regarding the preference by cattle of wetland meadows from late summer on, when the nutritional quality and palatability of the upland forage declines. The heaviest use by cattle of pinegrass, the major upland forage, was in September, and the overall use of sedges by cattle was less in August and September than in June and July. In addition, my own observations in 1978, a dry summer when more sedge meadows than usual were accessible to cattle, showed that by the end of August, both dry and wet meadows used by cattle were severely grazed and had sustained heavy trampling damage, to which sedge meadows are especially vulnerable (Millar, 1973; Heyes, 1979). From June through September, pinegrass formed the highest percent of any plant species in horse diets, the only species coming even close were _Poa juncifolia_ in June and _Carex aquatilis_ in July. Horses consistently utilized pinegrass roughly 1.5 to 2 times more than cattle.

Chapter 5: Summary

Comparative selectivity of food materials by monogastric herbivores (largely equids) and ruminants has been examined to some extent. Recently published data has led to a confusing and contradictory overlap of ideas. Traditionally, the prevailing idea has been that ruminants were ideally suited to deal with forages of poor nutritive quality (Swenson, 1970). However, such factors as the need for sufficient bacterial energy and the relatively slow rate of passage, hinder the utilization of poor quality forage by ruminants such as cattle (Janis, 1976; Ørskov, 1975; Hogan and Weston, 1970; Annison, 1970; Corbett, 1969). Other ruminants, such as deer, require a high diet quality in summer to produce the fat reserve they depend upon in the winter (Short, 1981). Deer cannot digest large amounts of cellulose (Nagy, 1969) and have a very limited capacity for increasing food intake to accommodate for decreased food quality (Amman et al., 1973 cited in Wallmo et al., 1977). Subsequently they tend to be highly selective in their choice of food in both summer and winter (Mackie et al., 1982; Short, 1981). Until quite recently, it was assumed that the horse required high quality forage, but recent evidence indicates the ability of equids in general to exploit environments which are either optimal or sub-optimal for ruminants. This is due to their much greater tolerance of high fiber content in the diet than ruminants (Janis, 1976). In both North America (Olsen and Hansen, 1977) and Africa (Bell, 1971; 1970) the results of field studies have shown ruminant feeding strategy to be more selective for digestible tissue than that of equids. Data collected by Bell (1970) in a study of herbage use by zebra (Equus burchelli bohmi) compared to four ruminant species showed that zebra: 1) Selected a diet with the lowest protein content, 2) utilized the highest amount of roughage, and 3) chose the commonest and most accessible herbage.

Although horses and cows are both grazers, they are representative of two completely different mammalian families with different digestive strategies. Subsequently, though convergent in the niche they exploit, they remain divergent in 'how' they exploit the niche. To date, the general consensus, expressed by Evans (1977) is that horses are approximately two-thirds as efficient in the digestion of fiber as ruminants, and this is probably true when equal amounts of feeds of varying fiber levels are fed ad libitum. However, there are a number of other factors to consider:

1) The horse, with more efficient direct utilization of dietary soluble carbohydrates and dietary protein sources, depends less on products of bacterial digestion (and bacterial protein) than do cattle.

2) The rate of passage of digesta is faster in the horse enabling more food to be processed in the same time period (Alexander, 1963; Vander Noot et al., 1967) than ruminants, while the cellulolytic activity of the caecum remains comparable to that of the rumen (Balch and Johnson, 1950 (cited in Robinson and Slade, 1974); Alexander, 1963).

3) The horse seems to be able to switch easily from extensive

dependence on monogastric digestion to equal dependence on bacterial digestion without an 'adjustment' period such as that required by ruminants (Slade et al., 1970).

4) Under identical experimental conditions, absorption of the major products of bacterial fermentation, the volatile fatty acids, has been shown to be similar for the equine large intestine and the ruminant forestomach (Stevens and Stettler, 1966; Argenzio et al., 1974b).

Janis (1976) suggests the equid strategy may be essential for the use of herbage above a given fiber level and, whereas the greater quantity of food required by horses under adverse circumstances might be interpreted as inefficient, Janis points out that this digestive strategy enables horses to exist on a diet which ruminants of similar body size simply cannot maintain themselves. Horses may well prove to be 'optimal foragers' by becoming selective, i.e. a 'specialist,' when there is food in abundance, and unselective, i.e. a 'generalist,' when food is scarce (Pyke et al., 1977; Nudds, 1980; Belovsky, 1978).

A number of large herbivores have been shown to have highly variable diets, depending on their geographical location and environment. This adaptability is true for moose (Franzman, 1978; Peek, 1974), mule deer (Short, 1981) and elk (Boyd, 1978). Diet studies conducted on feral horses and range cattle, either separately, together or with other species, have shown adaptability to various environments (Casebeer and Koss, 1970; Welsh, 1975; Feist and McCullough, 1976; Leuthold, 1977; Berger, 1975). For example, in the Red Desert of Wyoming, year-round dominant foods of horses were Agropyron spp. (37%) and Stipa spp. (36%); and for cattle, the only single significant forage was Agropyron spp. (54%) (Olsen and Hansen, 1977). In dry mountain range in southern Colorado, the dominant summer forages of cattle were Danthonia spp. and Fescue spp., while in the fall Carex spp. increased to 58% of the diet (Hansen and Reid, 1978). On the dry, White Sands Missile Base in southern New Mexico, the dominant foods of horses in the summer were dropseed (Sporobolus spp.) and mesquite (Prosopis juliflora) and russian thistle (Salsola kali) in winter (Hansen, 1976). The limited amount of comparative work conducted on horses and cattle has shown a tendency for the two herbivores to select similar forages within the different environments (Hubbard and Hansen, 1976; Salter, 1978; Hansen and Clark, 1977; Hansen et al., 1977; Olsen and Hansen, 1977). However, distinct differences have also been seen in all of the studies to date. In general, there has been little attempt to coordinate diet analysis with habitat-use and distribution studies; and in some instances so many data have been 'lumped' that the results are of little value in interpreting the signficance of potential animal interactions. In an article by Hansen et al., (1977), the annual dietary overlap for horses and cows was determined to be 77 percent, but fecal material was collected without regard to season, vegetation analysis, animal movements, habitat preference or apparent age (i.e. deterioration) of feces other than it being 'undecomposed.' The 77 percent similarity in diet choice may be valid, but it is only a small part of the whole picture, as interactions between herbivores may be subtle.

To date, most diet studies involving feral horses and other species have utilized a 'similarity index' to indicate what percentage of a pair of diets was identical, and this has been directly interpreted as diet overlap (Hubbard and Hansen, 1976; Salter, 1978; Hansen and Clark, 1977; Seegmiller and Ohmart, 1981; Hansen et al., 1977; Olsen and Hansen, 1977). The similarity index is based on summing the percentage use in common of shared forages by two or more animal species (Anthony and Smith, 1977; Oosting, 1956). In the present study, a similarity index for the average use of the dominant 11 forages shared by horses and cows was nearly 70 percent (69.7%). I feel that, unless rather stringent restrictions are placed on interpretation of diet overlap, a percentage use of identical plant species may tend to obscure thinking and bias it towards misuse of the concept of competition. The most confusing aspect of the concept of diet overlap is that it implies 'sameness,' i.e. the use of the particular plant species in the same way, in the same place and at the same time, whereas in reality, these are all independent components, each of which can greatly alter the degree of 'sameness,' or essentially negate it altogether. Results from my study summarized below, show that differences as well as similarities exist in the way horses, cows and moose utilize their environment, and indicates the need for a comprehensive approach to the investigation of herbivore interactions:

1) It was determined that the distribution of habitat types in the approximately 200 sq km of the study site was as follows: Open Forest (14.5%), Semi-open Forest (33.4%), Closed Forest (13.7%), Meadow (28.1%), Shrub carr (2.6%), Interface Zone (5.7%) and 'Other' (1.9%).

2) Forested habitat, including Open Forest, Semi-open Forest, Closed Forest and Interface Zone, comprised a total of 67.3 percent of the area.

3) Moose appeared to be attracted to Forest Habitat, as 78 percent of all fecal counts were made in forest, whereas the highest fecal counts for horses (65.3%) and cows (76%), were made in open habitat (i.e. meadow and shrub carr).

4) Cows used Meadow and Interface zone disproportionately more than it was available, as did horses for Meadow and moose for Open and Closed Forest, and Shrub carr.

5) On the basis of fecal concentrations, horses were found to use contiguous forest (i.e. forest not in conjunction with open habitats) more than cows, the latter tending to use Interface Zones (i.e. forest in conjunction with open habitats) more than horses.

6) Moose were found to use those habitat types (i.e. Open, Semi-open and Closed forest and Shrub carr) that horses and, particularly, cows used least.

7) All three herbivores showed some species specific selection

for the available habitats.

8) The five transects all varied significantly in regard to the relative amounts of each habitat type.

9) The highest fecal counts for each herbivore species were made on different transects. Cows used T-IV the most which had the highest percentage of both meadow and interface zone, horses used T-I the most, having the largest amount of contiguous forest, and moose used T-V the most, which had the highest amount of Shrub carr, a habitat type moose used more than its percent availability would have indicated.

10) Although fecal counts indicated horses and cows selected for Meadow habitat most strongly, there was no evidence that forage availability plays a major role in habitat selection, as the dominant forage in both horse and cattle diets is a forest species (C. rubescens), not found in meadow habitat in the study area.

11) Based on food habits established for moose in the literature, forage availability did not seem to play a dominant role in their habitat selection, as their highest fecal counts were made in closed forest, with a low food availability.

12) When the levels of spatial association were evaluated, horses and cattle were seen to be associated, while cattle and moose were seen to be separate, and horses and moose were neither associated nor separate.

13) However, the five transect graphs showed that the concentration of use in any given area varied widely between species.

14) Based on approximately equal average defecation rates, cattle populations for the study area were estimated to be 90% of the total horse, cattle, moose herbivore population; and horses and moose were estimated to have population levels of 7.4% and 2.9%, respectively.

15) Despite the large difference in cow versus horse populations, and the relatively limited amount of meadow habitat (28.1%), the transect graphs showed numerous instances where horses were heavily concentrated in areas cattle used very slightly, and vice versa.

16) A trend was seen for horses to use 'isolated' meadows (i.e. those surrounded by extensive forest areas) and contiguous forest areas much more than cattle, which tended to use habitual travel routes linking meadows. Subsequently, despite the association indicated for horses and cattle, they were distributed differently over the study area.

17) A 'long-term' and 'short-term' comparison of fecal material was made on T-V, and two graphs made, which were shown to be statistically different. However, although the graphical comparison indicated that overall distribution patterns of the three species were somewhat different over time, there were certain consistencies in habitat

preference, including the pronounced use of T-V by moose; the use by horses, but only slightly by cattle, of 'isolated' meadows; and the 'absence' of cattle in contiguous forest areas.

18) Diet analysis indicated that both cattle and horses, from June through September, were exercising a fairly high degree of selectivity in their choice of forages. Eleven forages comprised 86% for horses, and 80% for cattle, of the total diet. These 11 forages represented only 7.4% of the 148 plant species identified on the study area.

19) Differences were found to exist in the apparent foraging patterns of horses and cows on the basis of the average amount consumed of a plant species per month; differences in the ways a forage plant was used by horses and cattle; and whether a particular month was critical in an interaction context.

20) An analysis of the proportionate use of botanical groups by horses and cattle showed a significant difference in their utilization per month of grasses, rush-sedges and 'other' (i.e. mainly forbs and browse).

21) In summer diets, horses utilized an average of 61% grasses, whereas cows used an average of 51% grasses, with a higher proportion of sedges, forbs and browse, indicating cows were somewhat more selective for forage with lower fiber content.

22) In winter, horses decreased the number of grass, sedge and forb species eaten, and increased their utilization of shrub material up to 14.7%.

23) Also, in winter, horses increased their dependence on Rush-sedges, from 33.2% average in the summer months, to 48% in winter.

24) Because horses were considered able to exploit the green, inner material found in sedge plants during the winter, a nutrient analysis was done on the selected green material. This was found to have a Crude Protein level of 6.5%, consistently higher than CP values reported for grass types found on the study site, in a 'weathered' condition, collected in late fall or winter. Horse use of grasses dropped dramatically in the winter (from 60% to 35%).

25) Although horses utilize Carex aquatilis and Carex rostata heavily in the winter (28.5%) which are both grazed by horses and cows during the summer, the single most important winter forage plant for horses was Juncus balticus, utilized 17.2%, and used only very moderately by either herbivore in the summer.

26) The diet analysis showed an increase in the use of conifer needles during the winter (6.3%). This was not considered accidental because of the discriminating ability of horses.

27) The total diets of horses and cattle represented only a fraction of the plant species comprising the botanical

groups found on the study site. Horses and cows used only 6 of the 13 available rush-sedge species; of 88 forbs, horses used 16 and cattle 20, and of 43 grass species, horses used 22 and cattle 19.

28) The dominant forage for both horses and cattle was _C. rubescens_, or pinegrass, although _Carex aquatilis_ was used only slightly less by cattle. Horses, however, utilized _C. rubescens_ 16% more than the next favorite, _C. aquatilis_.

29) Horses always used more _C. rubescens_ (i.e. every month from June through September), and cattle always used more _C. aquatilis_ than horses. The use of _C. rubescens_ by cattle increased from June through September.

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APPENDIX 1:

List of plants identified on the study site during 1979 and 1980.

List of plants identified on the study site during 1979 and 1980: A total of 148 species were identified at least to species level.

FAMILY	GENUS SPECIES	COMMON NAME
1. BETULACEAE (birch family)	Betula glandulosa (2 varieties)	Bog or Scrub birch
2. BORAGINACEAE (borage family)	Myosotis sylvatica	Forget-me-not
	Lithospermum ruderale	Lemon-weed
3. CAPRIFOLIACEAE (honeysuckle family)	Linnaea borealis	Twin-flower
	Symphoricarpos albus	Waxberry/Snowberry
4. CARYOPHYLLACEAE (pink family)	Cerastium arvense	Field chickweed
	Arenaria lateriflora	Blunt-leaf sandwort
	Stellaria longipes	Long-stalk starwort
	Lychnis drummondii	Drummond campion
5. COMPOSITAE (aster family)	Erigeron speciosus	Large purple fleabane
	E. philadelphicus	Philadelphia fleabane
	E. loncophyllus	Spear-leaved fleabane
	E. compositus	Cut-leaved fleabane
	E. flagellaria	---
	Aster eatonii	Eaton's aster
	A. ciliolatus	Lindley's aster
	A. conspicuous	Large purple aster
	A. pansus	Tufted white prairie aster

continued...

Appendix 1 (cont.)

A. compestris	Meadow aster
Antennaria parvifolia	Nuttall's pussytoes
A. microphylla	Rosy pussytoes
A. pulcherrima	Showy pussytoes
Antennaria neglecta	Field pussytoes
A. umbrinella	Umber pussytoes
Artemesia frigida	Pasture wormwood/ Sagewort
Senecio streptanthifolius	Groundsel/Ragwort
S. canus	
Crepis tectorum	Narrow-leaved hawksbeard
Arnica cordifolia	Heart-leaved arnica
A. fulgens	Twin arnica
A. chamissonis var. incana	---
Achillea millefolium	Yarrow
Solidago canadensis	Canada/Meadow goldenrod
S. spathulata	Spike-like goldenrod
Agoseris glauca	Pale agoseris
Cirsium sp.	Thistle
Taraxacum officinale	Common dandelion
Tragopogon pratensis	Goatsbeard/Salsify

continued...

Appendix 1 (cont.)

	Hieracium scouleri	Hounds-tongue
	Grindelia squarrosa	Curly-gup gumweed
6. CRASSULACEAE (stonecrop family)	Sedum lanceolatum	Lance-leaved stonecrop
7. CRUCIFERAE (mustard family)	Descurainia richardsonii	Tansy mustard
	Lepidium virginicum	Tall peppergrass
	Arabis sp.	Rockcress
8. CUPRESSACEAE (juniper family)	Juniperus communis	Common juniper
9. CYPERACEAE (sedge family)	Carex aquatilis	Water sedge
	C. rostrata	Beaked sedge
	C. sitchensis	Sitka sedge
	C. praegracilis	Clustered field sedge
	C. petasata	Liddon's sedge
	C. concinnoides	N. western sedge
	C. concinna	Low N. sedge
	C. lasiocarpa	Slender sedge
	C. aurea	Golden sedge
	C. parryana	Parry sedge
	C. atherodes	Awned sedge
	C. pachystachya	Thick-headed sedge
	Eleocharis sp.	Spike rush

continued...

Appendix 1 (cont.)

10. ELAEAGNACEAE (oleaster family)	Shepherdia canadensis	Buffalo berry
11. ERICACEAE (heath family)	Pyrola chlorantha	Greenish wintergreen
	P. (monensis) uniflora	Woodnymph
	P. asarifolia	Common pink wintergreen
	Arctostaphylos uva-ursi	Kinnikinnick/Bearberry
12. GENTIANACEAE (gentian family)	Gentiana amarella	N. gentian
13. GRAMINAE (grass family)	Oryzopsis asperifolia	Ricegrass
	O. pungens	
	Stipa richardsonii	Richardson needlegrass
	S. spartea	Porcupine grass
	S. comata	Needle-and-thread grass
	S. occidentalis	W. needlegrass
	Beckmannia sp.	Sloughgrass
	Hordeum jubatum	Foxtail barley
	H. brachyantherum	Meadow barley
	Calamagrostis rubescens	Pinegrass
	C. neglecta	Reedgrass
	C. inexpansa	N. Reedgrass

continued...

Appendix 1 (cont.)

Puccinellia nuttalliana (airoides)	Nuttall alkali grass
Poa juncifolia	Alkali bluegrass
P. interior	Inland bluegrass
P. pratensis	Kentucky bluegrass
Agropyron spicatum	Bluebunch wheatgrass
A. trachycaulum (3 varieties)	Beardless wheatgrass
Spartina gracilis	Alkali cordgrass
Koeleria micrantha (cristata)	June grass
Muhlenbergia richardsonis	Mat muhly
Festuca saximontana (ovina)	Sheep fescue
Danthonia intermedia	Timber oatgrass
Bromus anomalus	Nodding brome
Alopecurus aequalis	Short-awn foxtail
Glyceria borealis	N. mannagrass
Deschampsia caespitosa	Tufted hairgrass
Agrostis scabra	Bentgrass

continued...

Appendix 1 (cont.)

	Distichlis spicata var. stricta	Desert saltgrass
14. GROSSULARIACEAE (currant family)	Ribes sp.	Gooseberry
15. HIPPURIDACEAE (mare's tail family)	Hippuris vulgaris	Common mare's tail
16. IRIDACEAE (Iris family)	Sisyrinchium angustifolium	Blue-eyed grass
17. JUNCACEAE (Rush family)	Juncus balticus	Baltic rush
18. JUNCAGINACEAE (arrowgrass family)	Triglochin maritimum	Seaside arrowgrass
19. LILIACEAE (lily family)	Smilacina stellata	Star-flowered Solomon's seal
	Zigadenus venenosus	Meadow death camus
	Allium cernuum	Nodding onion
20. LEGUMINOSAE (legume family)	Astragalus miser	Timber milk vetch
	A. alpinus	---
	Vicia americana	American vetch
	Lathyrus ochroleucus	Yellow pea
	Oxytropis deflexa	Pendent-pod crazyweed

continued...

Appendix 1 (cont.)

21. LINACEAE (flax family)	Linum perenne var. lewisii	Wild blue flax
22. ONAGRACEAE (eve. primrose family)	Epilobium angustifolium	Narrow-leaved fireweed
23. ORCHIDACEAE (orchid family)	Orchis rotundifolia	Round-leaved orchid
	Spiranthus romanzoffiana	Ladies-tresses
24. POLEMONIACEAE (phlox family)	Polemonium humile	Jacob's ladder
25. POLYGONACEAE (buckwheat family)	Eriogonum heracleoides	Parsnip-flowered eriogonum
	Rumex sp.	Dock/Sorrel
	Polygonum sp.	Smartweed/Knotweed
26. RANUNCULACEAE (buttercup family)	Ranunculus cymbalaria	Shore buttercup
	Anemone multifida	Globe anemone
	Aquilegia brevistyla	Blue columbine
	Thalictrum sp.	Meadow rue
27. ROSACEAE (rose family)	Geum triflorum	Old man's whiskers
	Fragaria virginiana var. glauca	Wild strawberry

continued...

	Potentilla anserina	Silver leaf cinquefoil
	P. gracilis	Tall yellow cinquefoil
	P. hippiana	Wooly cinquefoil
	P. pensylvanicus	Prairie cinquefoil
	Rosa acicularis	Prickly rose
	Spiraea betulifolia	Flat-topped spirea
	Amelanchier sp.	Saskatoon berry
28. RUBIACEAE (madder family)	Galium boreale	N. bedstraw
29. SALICACEAE (willow family)	Salix spp.	Willow
30. SANTALACEAE (sandalwood family)	Comandra livida	Bastard toadflax
	C. umbellata var. pallida	Pale comandra
31. SAXIFRAGACEAE (saxifrage family)	Heuchera cylindrica	Round-leaf alum root
	Parnassia palustris	N. grass of parnassus
32. SCROPHULARIACEAE (figwort family)	Penstemon fruticosus	Shrubby penstemon
	P. procerus	Slender blue penstemon
	Castilleja miniata	Indian paint brush
	Orthocarpus luteus	Yellow owl clover

continued...

Appendix 1 (cont.)

33. UMBELLIFERAE (parsley family)	Lomatium macrocarpum	Large-fruit lomatium
34. VIOLACEAE (violet family)	Viola adunca	Blue violet

TREES:

35. PINACEAE (pine family)	Picea glauca	White spruce
	P. englemannii	Englemann spruce
	Pinus contorta var. latifolia	Lodgepole pine
	Pseudotsuga menziesii	Douglas fir
36. SALICACEAE (willow family)	Populus tremuloides	Trembling aspen

OTHER:

LICHENS	Peltigera sp.	---
	Cladonia sp.	Reindeer lichen

APPENDIX 2:

Horse and Cattle Diets - determined by fecal analysis

HORSE DIET - JUNE

Diet H - I

Plant Species	% Diet
Poa juncifolia	21.7
Juncus balticus	13.5
Carex aquatilis	12.3
Calamagrostis rubescens	12.1
Stipa comata	11.0
Carex rostata	5.4
Carex atheroides	4.8
Agropyron	4.4
Hordeum jubatum	4.2
Carex concinoides	3.0
Glyceria borealis	2.6
Stipa richardsonii	2.3
Calamagrostis neglecta	0.9
Muhlenburgia richardsonis	0.8
Stipa occidentalis	0.7
Oryzopsis asperifolia	0.3

Diet H - 2

Plant Species	% Diet
Poa juncifolia	19.3
Calamagrostis rubescens	16.8
Juncus balticus	14.2
Carex rostrata	11.0
Carex aquatilis	8.7
Stipa comata	7.8
Carex atheroides	6.3
Glyceria borealis	4.8
Hordeum jubatum	4.1
Carex concinoides	2.1
Muhlenburgia richardsonis	1.7
Stipa richarsonii	1.2
Alopecurus aequalis	0.9
Oryzopsis asperifolia	0.7
Calamagrostis neglecta	0.4

HORSE DIET - JUNE

Diet H - 3

Plant Species	% Diet
Calamagrostis rubescens	19.5
Poa juncifolia	17.4
Hordeum jubatum	9.9
Juncus balticus	10.6
Calamagrostis neglecta	8.4
Carex aquatilis	8.1
Carex rostata	7.3
Stipa comata	5.9
Carex atheroides	2.7
Rush-Sedges	2.0
Stipa richardsonii	1.5
Oryzopsis asperifolia	1.2
Poa Interior	1.2
Eleocharis	1.0
Agropyron	0.7
Muhlenburgia richardsonis	0.6
Agrostis	0.5
Potentilla hippiana	0.5

Diet H - 4

Plant Species	% Diet
Calamagrostis rubescens	25.8
Poa juncifolia	12.6
Calamagrostis neglecta	9.4
Carex aquatilis	7.1
Carex rostata	7.1
Stipa comata	6.2
Hordeum jubatum	4.2
Juncus balticus	4.0
Glyceria borealis	3.6
Carex concinoides	3.6
Carex atheroides	3.4
Rush-Sedges	3.2
Stipa occidentalis	2.3
Oryzopsis asperifolia	1.8
Sisyrinchium	1.2
Muhlenburgia richardsonis	1.0
Stipa richardsonii	0.6
Geum triflorum	0.5
Achillea millefolium	0.4
Astragalus miser	0.3
Hippuris vulgaris	0.3
Aster conspicuous	0.3
Spartina gracilis	0.3
Potentilla hippiana	0.3
Beckmanaia sp.	0.3
Taraxacum officinale	0.2

HORSE DIET - JULY

Diet H - 1

Plant Species	% Diet
Carex aquatilis	26.3
Poa juncifolia	11.9
Calamagrostis rubescens	10.1
Calamagrostis neglecta	7.0
Carex rostata	5.9
Carex concinoides	5.4
Juncus balticus	4.8
Stipa comata	4.5
Stipa occidentalis	4.1
Hordeum jubatum	3.9
Glyceria borealis	3.7
Carex atheroides	2.8
Sedges-Rush	2.2
Juncus/Eleocharis	1.8
Rosa acicularis	1.2
Muhlenburgia richarsonis	1.2
Oryzopsis asperfolia	1.1
Beckmania sp.	0.8
Unknown forb	0.6
Spartina gracilis	0.5
Potentilla hippiana	0.1
Aster conspicuous	0.1

Diet H - 2

Plant Species	% Diet
Poa juncifolia	14.3
Calamagrostis rubescens	12.6
Carex aquatilis	11.2
Calamagrostis neglecta	10.5
Juncus balticus	9.2
Stipa comata	8.1
Hordeum jubatum	6.8
Carex rostata	6.7
Glyceria borealis	3.7
Juncus/Eleocharis	3.5
Stipa occidentalis	2.4
Carex concinoides	1.9
Sedges-Rush	1.6
Fragaria virginiana	1.5
Carex atheroides	1.2
Oryzopsis asperifolia	1.1
Muhlenburgia richarsonis	1.0
Potentilla hippiana	0.9
Astragalus miser	0.6
Unknown grass	1.2

HORSE DIET - JULY

Diet H - 3

Plant Species	% Diet
Calamagrostis rubescens	22.3
Juncus/Eleocharis	16.9
Stipa occidentalis	12.7
Carex aquatilis	7.9
Poa juncifolia	6.4
Carex rostata	5.4
Hordeum jubatum	5.2
Stipa comata	4.8
Calamgrostis neglecta	4.1
Spartina gracilis	3.3
Glyceria borealis	2.8
Stipa richardsonii	2.5
Oryzopsis asperifolia	2.5
Forb flower	2.4
Taraxacum officinale	0.5
Muhlenburgia richardsonis	0.4

Diet H - 4

Plant Species	% Diet
Calamagrostis rubescens	18.3
Carex aquatilis	16.0
Carex rostata	10.5
Juncus/Eleocharis	7.7
Stipa comata	6.8
Carex concinoides	5.2
Stipa occidentalis	5.2
Carex atheroides	4.4
Glyceria borealis	4.2
Poa juncifolia	3.6
Stipa richardsonii	3.6
Calamagrostis neglecta	3.3
Juncus balticus	3.0
Hordeum jubatum	1.7
Oryzopsis asperifolia	1.7
Achillea millefolium	1.4
Rosa acicularis	1.1
Artemesia frigida	1.0
Muhlenburgia richardsonis	0.7
Unknown forb	0.6

HORSE DIET - AUGUST

Diet H - 1

Plant Species	% Diet
Calamagrostis rubescens	27.6
Carex concinoides	11.9
Stipa occidentalis	9.7
Carex rostata	8.9
Carex atheroides	6.9
Juncus balticus	5.8
Poa juncifolia	5.6
Carex aquatilis	4.6
Unknown Grass	4.3
Astragalus miser	4.1
Monocot Forb	3.0
Oryzopsis asperifolia	1.9
Glyceria borealis	1.3
Juncus sp.	1.0
Hordeum jubatum	0.9
Calamagrostis neglecta	0.8
Unknown Forb	0.7
Achillea millefolium	0.7
Spiraea betulifolia	0.3

Diet H - 2

Plant Species	% Diet
Calamagrostis rubescens	62.7
Stipa occidentalis	7.2
Carex aquatilis	7.2
Carex rostata	6.9
Juncus balticus	5.9
Stipa comata	2.5
Hordeum jubatum	1.7
Glyceria borealis	1.4
Carex atheroides	1.2
Poa juncifolia	0.8
Calamagrostis neglecta	0.8
Juncus sp.	0.8
Achillea millefolium	0.7
Unknown Forb	0.2

Diet H - 3

Plant Species	% Diet
Calamagrostis rubescens	46.2
Carex rostata	8.2
Juncus/Eleocharis	7.5
Carex aquatilis	6.5
Stipa occidentalis	6.4
Poa juncifolia	5.6
Stipa comata	3.2
Hordeum jubatum	2.7
Juncus balticus	2.3
Juncus sp.	1.8
Carex concinoides	1.7
Stipa richardsonis	1.5
Oryzopsis asperifolia	1.5
Astragalus miser	1.5
Calamagrostis neglecta	1.4
Glyceria borealis	1.2
Muhlenburgia richardsonii	0.5
Antennaria parviflora	0.3

Diet H - 4

Plant Species	% Diet
Calamagrostis rubescens	31.8
Carex aquatilis	20.2
Carex rostata	12.9
Carex concinoides	7.3
Juncus balticus	5.9
Hordeum jubatum	4.6
Poa juncifolia	4.0
Glyceria borealis	3.3
Stipa occidentalis	2.8
Carex atheroides	2.7
Calamagrostis neglecta	2.0
Juncus sp.	1.2
Astragalus miser	0.7
Arctostaphylos uva-ursi	0.6

HORSE DIET - SEPTEMBER

Diet H - 1

Plant Species	% Diet
Calamagrostis rubescens	47.3
Carex rostata	13.5
Carex aquatilis	9.4
Poa juncifolia	7.0
Carex concinoides	6.9
Stipa occidentalis	4.5
Juncus balticus	2.9
Astragalus miser	1.7
Hordeum jubatum	1.6
Carex atheroides	1.2
Glyceria borealis	0.9
Calamagrostis neglecta	0.7
Spartina gracilis	0.5
Stipa comata	0.5
Oryzopsis asperifolia	0.4
Arnica cordifolia	0.3
Rosa acicularis	0.3
Forb Flower	0.3
Monocot Forb	0.1

Diet H - 2

Plant Species	% Diet
Calamagrostis rubescens	45.3
Poa juncifolia	8.1
Carex aquatilis	7.2
Carex rostata	7.2
Stipa occidentalis	5.4
Calamagrostis neglecta	3.7
Juncus/Eleocharis	2.9
Carex concinoides	2.4
Hordeum jubatum	2.3
Glyceria borealis	2.3
Juncus sp.	2.1
Stipa comata	1.7
Oryzopsis asperifolia	1.2
Muhlenburgia richardsonis	1.1
Unknown Forb	1.0
Astragalus miser	0.8
Unknown Grass	0.8
Potentilla hippiana	0.8
Achillea millefolium	0.7
Sheperdia canadensis	0.7
Sedum lanceolatum	0.6
Juniperus sp.	0.6
Betula glandulosa	0.4
Carex atheroides	0.4
Rosa acicularis	0.3

HORSE DIET - SEPTEMBER

Diet H - 3

Plant Species	% Diet
Carex rostata	14.4
Calamagrostis neglecta	11.4
Carex aquatilis	10.6
Calamagrostis rubescens	9.4
Carex concinoides	9.1
Poa juncifolia	8.9
Unknown Shrubs	5.9
Juncus sp.	5.6
Glyceria borealis	4.7
Stipa occidentalis	3.8
Unknown Forb	2.7
Stipa comata	2.6
Monocot Forb	2.1
Grass Seed	1.8
Muhlenburgia richardsonis	1.5
Hordeum jubatum	1.4
Unknown Grass	1.2
Carex sp.	0.9
Astragalus miser	0.7
Vicia sp.	0.7
Pinus contorta	0.6

Diet H - 4

Plant Species	% Diet
Calamagrostis rubescens	18.0
Stipa occidentalis	10.1
Carex aquatilis	7.9
Poa juncifolia	6.5
Carex rostata	6.4
Juncus sp.	6.4
Calamagrostis neglecta	6.1
Glyceria borealis	5.4
Hordeum jubatum	4.3
Astagalus miser	3.3
Juncus/Eleocharis	3.0
Muhlenburgia richardsonis	2.6
Stipa comata	2.5
Eriogonum sp.	2.3
Unknown Grass	1.9
Potentilla hippiana	1.9
Carex concinoides	1.6
Pinus contorta	1.6
Unknown Forb	1.6
Beckmania sp.	1.4
Fern	1.2
Taraxacum officinale	0.9
Monocot forb	0.9
Vicia sp.	0.8
Unknown shrub	0.8
Arctostaphylos uva-ursi	0.6

HORSE DIETS - WINTER

Diet H - 1

Plant Species	% Diet
Carex rostata	17.9
Juncus sp.	15.5
Carex aquatilis	14.1
Glyceria borealis	8.3
Unknown Grass	6.9
Calamagrostis rubescens	6.5
Stipa occidentalis	6.0
Pinus contorta	4.5
Rosa acicularis	3.8
Poa juncifolia	2.6
Calamagrostis neglecta	2.5
Artemesia frigida	2.0
Juncus/Eleocharis	1.9
Betula glandulosa	1.6
Carex concinoides	1.5
Arctostaphylos uva-ursi	1.3
Picea sitchensis	1.2
Salix sp.	1.1
Unknown shrub	0.5
Fern	0.3

Diet H - 2

Plant Species	% Diet
Juncus sp.	18.8
Carex rostata	14.4
Carex aquatilis	10.6
Unknown Grass	9.4
Stipa comata	7.9
Calamagrostis rubescens	7.5
Unknown Shrub	5.3
Pinus contorta	4.3
Glyceria borealis	4.0
Stipa occidentalis	4.0
Calamagrostis neglecta	3.1
Picea sitchensis	2.7
Rosa acicularis	2.6
Fern	2.2
Antennaria parviflora	1.0
Carex concinoides	0.8
Poa juncifolia	0.7
Arctostaphylos uva-ursi	0.7

CATTLE DIETS - JUNE

Diet C - 1

Plant Species	% Diet
Poa juncifolia	10.7
Carex rostata	10.7
Calamagrostis rubescens	10.1
Rush-Sedges	9.8
Calamagrostis neglecta	9.7
Hordeum jubatum	9.3
Juncus balticus	7.3
Carex aquatilis	6.3
Glyceria borealis	4.8
Stipa comata	4.1
Carex concinoides	3.7
Carex atheroides	2.1
Muhlenburgia richardsonis	2.0
Hippuris vulgaris	1.7
Stipa richardsonii	1.3
Solidago spathulata	1.0
Viola adunca	0.9
Oryzopsis asperifolia	0.9
Fragaria virginiana	0.7
Potentilla hippiana	0.6
Stipa occidentalis	0.4
Astragalus miser	0.4
Antennaria parvifolia	0.3
Aster conspicuous	0.3
Achillea millefolium	0.3
Geum triflorum	0.3
Rosa acicularis	0.3

Diet C - 2

Plant Species	% Diet
Poa juncifolia	13.9
Carex aquatilis	13.2
Calamagrostis rubescens	12.9
Carex concinoides	12.6
Rush-Sedges	9.0
Carex rostata	6.3
Hordeum jubatum	5.3
Calamagrostis neglecta	4.3
Stipa comata	4.0
Glyceria borealis	4.0
Juncus balticus	3.9
Potentilia hippiana	2.8
Spartina gracilis	1.4
Carex atheroides	1.3
Stipa occidentalis	1.1
Oryzopsis asperifolia	1.0
Stipa richardsonii	0.9
Muhlenburgia richardsonis	0.7
Fragaria virginiana	0.6
Geum triflorum	0.2
Solidago spathulata	0.2
Aster conspicuous	0.1
Antennaria parvifolia	0.1
Astragalus miser	0.1

CATTLE DIETS - JUNE

Diet C - 3

Plant Species	% Diet
Calamagrostis rubescens	14.6
Carex aquatilis	12.7
Carex rostata	9.8
Poa juncifolia	9.7
Hordeum jubatum	7.5
Calamagrostis neglecta	8.5
Glyceria borealis	5.5
Stipa comata	5.0
Carex concinoides	3.9
Stipa occidentalis	3.8
Juncus balticus	3.3
Achillea millefolium	2.4
Potentilla hippiana	2.4
Sedge-Rush	1.7
Stipa richardsonii	1.5
Carex atheroides	1.3
Geum triflorum	0.8
Agropyron trachycaulum	0.7
Cerastium arvense	0.6
Astragalus miser	0.6
Fragaria virginiana	0.5
Unknown forb	0.5
Arnica cordifolia	0.4
Muhlenburgia richarsonis	0.4
Spartina gracilis	0.3
Taraxacum officinale	0.3
Solidago spathulata	0.3
Heuchera cylindrica	0.3
Penstemon procerus	0.3
Sedum lanceolatum	0.3
Aster conspicuous	0.1

Diet C - 4

Plant Species	% Diet
Carex aquatilis	14.7
Carex rostata	11.2
Carex atheroides	9.6
Calamagrostis neglecta	9.5
Hoedeum jubatum	8.5
Poa juncifolia	8.1
Carex concinoides	8.0
Calamagrostis rubescens	7.4
Juncus balticus	6.1
Stipa comata	4.8
Glyceria borealis	3.6
Stipa occidentalis	2.4
Sedge-Rush	2.4
Spartina gracilis	1.0
Sisyrinchium angustifolium	0.7
Arnica cordifolia	0.7
Muhlenburgia richardsonis	0.5
Astragalus miser	0.4
Aster conspicuous	0.3
Potentilla hippiana	0.1

CATTLE DIETS - JULY

Diet C - 1

Plant Species	% Diet
Carex aquatilis	15.8
Sedge-Rush	10.8
Calamagrostis neglecta	10.8
Calamagrostis rubescens	10.0
Glyceria borealis	8.4
Hordeum jubatum	6.3
Stipa comata	5.7
Carex rostata	5.1
Stipa occidentalis	4.9
Carex concinoides	4.3
Poa juncifolia	4.2
Juncus balticus	2.8
Rosa acicularis	2.4
Potentilla hippiana	1.6
Astragalus miser	1.2
Achillea millefolium	1.0
Carex atheriodes	1.0
Arnica cordifolia	0.8
Salix sp.	0.7
Unknown forb	0.7
Geum triflorum	0.6
Fragaria virginiana	0.6
Spartina gracilis	0.3

Diet C - 2

Plant Species	% Diet
Carex aquatilis	21.9
Glyceria borealis	9.2
Calamagrostis rubescens	8.5
Stipa occidentalis	7.8
Sedge-Rush	7.5
Stipa comata	7.4
Calamagrostis neglecta	5.5
Hordeum jubatum	4.8
Juncus balticus	4.2
Carex rostata	4.1
Poa juncifolia	3.3
Carex concinoides	2.3
Carex aquatilis	2.0
Muhlenburgia richardsonis	1.9
Oryzopsis asperifolia	1.7
Mosses	1.1
Potentilla hippiana	0.8
Rosa acicularis	0.8
Sedum lanceolatum	0.8
Stipa richardsonii	0.7
Spartina gracilis	0.7
Arctostaphylos uva-ursi	0.7
Penstemon procerus	0.5
Antennaria parvifolia	0.5
Aster conspicuous	0.2
Taraxacum officinale	0.2
Betula glandulosa	0.2
Achillea millefolium	0.2
Salix sp.	0.2
Unknown forb	0.2
Geum triflorum	0.1

CATTLE DIETS - JULY

Diet C - 3

Plant Species	% Diet
Carex aquatilis	20.9
Carex rostata	14.3
Calamagrostis rubescens	10.0
Hordeum jubatum	7.9
Calamagrostis neglecta	7.6
Glyceria borealis	6.8
Rush-Sedge	5.8
Stipa occidentalis	4.5
Poa juncifolia	3.8
Stipa comata	3.5
Muhlenburgia richardsonis	2.7
Juncus balticus	2.0
Carex concinoides	1.6
Oryzopsis asperifolia	1.6
Stipa richardsonii	1.4
Potentilla hippiana	1.0
Carex atheroides	0.9
Mosses	0.8
Unknown forb	0.6
Antennaria parvifolia	0.5
Achillea millefolium	0.3
Rosa acicularis	0.3
Fragaria virginiana	0.2
Aster conspicuous	0.2
Arnica cordifolia	0.2
Arctistaphylos uva-ursi	0.6

Diet C - 4

Plant Species	% Diet
Carex aquatilis	21.2
Carex rostata	13.1
Calamagrostis neglecta	13.0
Calamagrostis rubescens	11.8
Hordeum jubatum	9.5
Stipa occidentalis	9.0
Glyceria borealis	8.7
Carex atheroides	4.5
Stipa comata	2.9
Carex concinoides	1.1
Juncus balticus	0.8
Achillea millefolium	0.8
Muhlenburgia richardsonis	0.6
Potentilla hippiana	0.5
Aster conspicuous	0.5
Arctostaphylos uva-ursi	0.3
Taraxacum officinale	0.3
Astragalus miser	0.3
Salix sp.	0.2
Fragaria virginiana	0.2
Antennaria parvifolia	0.2

CATTLE DIET - AUGUST

Diet C - 1

Plant Species	% Diet
Carex aquatilis	16.2
Glyceria borealis	10.8
Stipa comata	10.0
Calamgrostis rubscens	9.3
Carex atheroides	8.7
Juncus balticus	8.1
Poa juncifolia	7.3
Carex rostata	5.9
Calamgrostis neglecta	4.9
Carex concinoides	3.8
Juncus/Eleocharis	2.9
Hordeum jubatum	2.7
Unknown forb	2.0
Stipa occidentalis	1.6
Stipa richardsonii	1.3
Potentilla hippiana	0.8
Oryzopsis asperifolia	0.7
Salix sp.	0.7
Astragalus miser	0.6
Shepherdia canadensis	0.5
Geum triflorum	0.4
Rosa acicularis	0.4
Aster conspicuous	0.2
Achillea millefolium	0.2

Diet C - 2

Plant Species	% Diet
Calamgrostis rubscens	25.1
Carex aquatilis	16.6
Poa juncifolia	5.6
Stipa comata	5.0
Stipa occidentalis	4.9
Carex rostata	3.5
Carex concinoides	3.5
Juncus/Eleocharis	3.4
Hordeum jubatum	3.2
Juncus balticus	2.7
Shepherdia canadensis	2.6
Calamagrostis neglecta	2.2
Oryzopsis asperifolia	2.2
Rosa acicularis	1.7
Sisyrinchium angustifolium	1.7
Muhlenburgia richardsonis	1.4
Vicia americana	1.4
Stipa richardsonii	1.3
Potentilla hippiana	1.3
Dicot forb	1.2
Geum triflorum	1.2
Salix sp.	1.2
Fragaria virginiana	1.1
Thalictrum sp.	1.1
Monocot forb	1.0
Antenaria sp.	0.7
Spiraea betulifolia	0.7
Arctostaphylos uva-ursi	0.5
Glyceria borealis	0.5
Betula	0.3
Aster consipcuous	0.3
Achillea millefolium	0.2
Solidago spathulata	0.2
Potentilla hippiana	0.2
Moss	0.1

CATTLE DIET - AUGUST

Diet C - 3

Plant Species	% Diet
Calamagrostis rubscens	28.1
Poa juncifolia	11.6
Carex rostata	10.8
Carex concinoides	8.2
Stipa occidentalis	6.5
Stipa comata	5.2
Rosa acicularis	3.4
Carex aquatilis	3.3
Juncus balticus	2.9
Glyceria borealis	2.7
Shepherdia canadensis	2.6
Muhlenburgia richardsonis	2.4
Oryzopsis asperifolia	1.7
Potentilla hippiana	1.6
Stipa richardsonii	1.3
Calamagrostis neglecta	1.2
Geum triflorum	1.2
Unknown forb	1.2
Juncus/Eleocharis	0.8
Beckmania	0.7
Achillea millefolium	0.6
Hordeum jubatum	0.6
Astragalus miser	0.6
Fragaria virginiana	0.4
Solidago spathulata	0.3

Diet C - 4

Plant Species	% Diet
Calamagrostis rubscens	22.2
Unknown form	15.0
Carex aquatilis	9.0
Stipa occidentalis	6.3
Juncus balticus	5.8
Carex rostata	4.5
Calamagrostis neglecta	4.5
Poa juncifolia	3.0
Stipa comata	2.8
Achillea millefolium	2.7
Carex concinoides	2.3
Sisyrinchium angustifolium	2.2
Hordeum jubatum	2.1
Spiraea betulifolia	2.0
Pinus contorta var. latifolia	1.8
Taraxacum officinale	1.7
Muhlenburgia richardsonis	1.4
Oryzopsis asperifolia	1.4
Forb flower	1.3
Potentilla hippiana	1.3
Arctostaphylos uva-ursi	1.1
Vicia americana	1.1
Salix sp.	1.0
Fragaria virginiana	1.0
Glyceria borealis	1.0
Shepherdia canadensis	0.9
Geum triflorum	0.4
Astragalus miser	0.2

CATTLE DIET - SEPTEMBER

Diet C - 1

Plant Species	% Diet
Calamagrostis rubescens	16.5
Carex rostata	9.6
Astragalus miser	8.4
Carex aquatilis	8.0
Glyceria borealis	7.7
Stipa occidentalis	7.2
Oryzopsis asperifolia	6.4
Juncus balticus	5.5
Achillea millefolium	4.9
Hordeum jubtaum	4.9
Carex conncinoides	4.3
Stipa comata	3.3
Vicia sp.	2.2
Beckmannia sp.	1.7
Muhlenburgia richardsonis	1.7
Cerastium arvense	1.5
Taraxacum officinale	1.3
Sisyrinchium angustifolium	1.2
Fragaria virginiana	1.0
Viola adunca	1.0
Poa juncifolia	1.0
Geum triflorum	0.5
Salix sp.	0.2

Diet C - 2

Plant Species	% Diet
Calamagrostis rubescens	29.0
Carex aquatilis	15.6
Juncus balticus	7.1
Poa juncifolia	6.0
Stipa comata	5.3
Stipa occidentalis	5.2
Carex rostata	4.4
Glyceria borealis	3.4
Hordeum jubatum	3.9
Vicia sp.	3.1
Stipa richardsonii	2.4
Fragaria virginiana	2.0
Potentilla hippiana	1.6
Sheperdia canadensis	1.5
Viola adunca	1.2
Oryzopsis asperifolia	1.1
Astragalus miser	0.9
Spiraea betulifolia	0.9
Beckmannia sp.	0.9
Achillea millefolum	0.8
Pinus contorta	0.8
Carex concinoides	0.8
Muhlenburgia richardsonis	0.7
Arnica cordifolia	0.5
Calamagrostis neglecta	0.5
Geum triflorum	

CATTLE DIET - SEPTEMBER

Diet C - 3

Plant Species	% Diet
Carex aquatilis	29.6
Calamagrostis rubescens	25.5
Carex concinoides	7.6
Glyceria borealis	4.1
Juncus balticus	3.7
Stipa comata	3.6
Stipa occidentalis	3.5
Hordeum jubatum	2.8
Calamagrostis neglecta	2.7
Rosa acicularis	2.4
Poa juncifolia	2.3
Vicia sp.	1.9
Carex rostata	1.7
Salix sp.	1.4
Carex atheroides	1.4
Arctostaphylos uva-ursi	1.3
Spartina gracilis	1.1
Arnica cordifolia	1.0
Oryzopsis asperifolia	0.8
Sheperdia canadensis	0.6
Juncus/Eleocharis	0.6
Potentilla hippiana	0.4

Diet C - 4

Plant Species	% Diet
Carex aquatilis	31.8
Calamagrostis rubescens	23.5
Carex rostata	5.8
Hordeum jubatum	5.1
Stipa comata	5.0
Juncus balticus	4.6
Poa juncifolia	3.9
Stipa occidentalis	3.6
Salix sp.	2.9
Carex concinoides	2.6
Unknown forb	2.5
Pinus contorta	2.1
Unknown Grass	2.0
Sheperdia canadensis	1.8
Glyceria borealis	1.0
Astragalus miser	1.0
Calamagrostis neglecta	0.8

APPENDIX 3:

Paired 't' test for 'Long-term' versus 'Short-term' fecal counts on Transect V

Cows versus Cows

Data for Paired 't' test (with 36 d.f.) - Arcsin Transformation - (Sokal and Rohlf, 1969: 205) for comparison of 'Long-term' (old) versus 'Short-term' (new) fecal counts recorded on Transect V in .5 km units:

No.	Fecal Counts Old	Prop. of Tot. Transect-Old	No.	Fecal Counts New	Prop. of Tot. Transect-New
1.	286	5.4	1.	116	7.7
2.	289	5.4	2.	116	7.7
3.	425	7.9	3.	177	11.8
4.	416	7.8	4.	164	10.9
5.	231	4.3	5.	110	7.3
6.	259	4.9	6.	129	8.6
7.	292	5.5	7.	102	6.8
8.	384	7.2	8.	33	.1
9.	252	4.7	9.	68	4.5
10.	224	4.2	10.	61	4.1
11.	234	4.4	11.	76	5.1
12.	206	3.9	12.	9	.6
13.	165	3.1	13.	5	.3
14.	175	3.3	14.	20	1.3
15.	165	3.1	15.	61	4.1
16.	181	3.4	16.	9	.6
17.	33	.62	17.	1	.1
18.	24	.5	18.	0	0
19.	10	.2	19.	0	0
20.	4	.1	20.	0	0
21.	1	.02	21.	0	0
22.	14	.3	22.	0	0
23.	10	.2	23.	0	0
24.	1	.02	24.	0	0
25.	4	.1	25.	0	0
26.	3	.1	26.	0	0
27.	2	.04	27.	1	.1
28.	13	.2	28.	4	.23
29.	8	.2	29.	1	.1
30.	20	.4	30.	0	0
31.	167	3.1	31.	8	.5
32.	100	1.9	32.	16	1.1
33.	38	.7	33.	0	0

continued...

Appendix 3 - Cows versus Cows (cont.)

34.	41	.8	34.	2	.1
35.	94	1.8	35.	15	1.0
36.	287	5.4	36.	38	2.5
37.	278	5.2	37.	163	10.8
	5336			1505	

d = 55.38 $\quad$ $(d)^2 = 3066.94$

t = 2.35

d = 1.497 $\quad$ $d^2 = 622.23$

APPENDIX 3: Horses versus Horses

No.	Fecal Counts Old	Prop. of Tot. Transect-Old	No.	Fecal Counts New	Prop. of Tot. Transect-New
1.	23	1.2	1.	0	0
2.	19	1.0	2.	0	0
3.	33	1.8	3.	1	2.3
4.	23	1.2	4.	0	0
5.	15	.8	5.	0	0
6.	15	.8	6.	0	0
7.	9	.49	7.	0	0
8.	29	1.6	8.	1	2.3
9.	61	3.3	9.	0	0
10.	49	2.6	10.	2	4.6
11.	16	.86	11.	5	11.4
12.	164	8.8	12.	0	0
13.	129	6.9	13.	0	0
14.	134	7.2	14.	10	22.7
15.	245	13.2	15.	3	6.8
16.	102	5.5	16.	3	6.8
17.	40	2.2	17.	0	0
18.	30	1.6	18.	0	0
19.	22	1.2	19.	0	0
20.	3	.2	20.	0	0
21.	0	0	21.	0	0
22.	4	.2	22.	0	0
23.	220	11.9	23.	7	15.9
24.	32	1.7	24.	4	9.1
25.	96	5.2	25.	3	6.8
26.	14	.8	26.	0	0
27.	5	.27	27.	0	0
28.	54	2.9	28.	0	0
29.	27	1.5	29.	0	0
30.	12	.65	30.	1	2.3
31.	37	2.0	31.	0	0
32.	28	1.5	32.	0	0
33.	20	1.1	33.	0	0
34.	20	1.1	34.	0	0
35.	25	1.4	35.	0	0
36.	56	3.0	36.	1	2.3
37.	46	2.5	37.	3	6.8
	1857			44	

$d = 105.8$ $(d)^2 = 11{,}193.6$ d.f. = 36

$d = 2.859$ $d^2 = 2036.3$ ArcSin = % = x

$t = 2.51$ InvSin x = ArcSin

APPENDIX 3: Moose versus Moose

No.	Fecal Counts Old	Prop. of Tot. Transect-Old	No.	Fecal Counts New	Prop. of Tot. Transect-New
1.	0	0	1.	0	0
2.	2	.31	2.	0	0
3.	0	0	3.	0	0
4.	0	0	4.	0	0
5.	0	0	5.	0	0
6.	1	.2	6.	0	0
7.	3	.46	7.	0	0
8.	6	.93	8.	0	0
9.	7	1.1	9.	0	0
10.	7	1.1	10.	0	0
11.	6	.93	11.	1	1.6
12.	8	1.2	12.	0	0
13.	9	1.4	13.	0	0
14.	15	2.3	14.	0	0
15.	95	14.7	15.	14	22.6
16.	52	8.0	16.	4	6.5
17.	30	4.6	17.	4	6.5
18.	5	.8	18.	2	3.2
19.	15	2.3	19.	5	8.1
20.	6	.93	20.	2	3.2
21.	14	2.2	21.	1	1.6
22.	10	1.5	22.	0	0
23.	16	2.5	23.	0	0
24.	34	5.3	24.	2	3.2
25.	13	2.0	25.	5	8.1
26.	25	3.9	26.	6	9.7
27.	26	4.0	27.	0	0
28.	32	4.9	28.	6	9.7
29.	15	2.3	29.	0	0
30.	33	5.1	30.	1	1.6
31.	8	1.2	31.	0	0
32.	8	1.2	32.	0	0
33.	3	.46	33.	2	3.2
34.	14	2.2	34.	0	0
35.	30	4.6	35.	0	0
36.	68	10.5	36.	4	6.5
37.	31		37.	3	4.8
	647			62	

$d = 91.4$ $\quad (d)^2 = 8353.96$

$d = 2.469$ $\quad d^2 = 1358.3$

$t = 2.675$

APPENDIX 4:

Presence of plant species identified in the original 10 habitat types designated

Plant species present in one or more of the original habitat types (Section 2.5) (Present = x)

Plant Species	Original Habitat Type									
Grasses-Rushes-Sedges	1	2	3	4	5	6	7	8	9	10
Calamagrostis rubescens	x	x	x	x			x	x	x	x
Oryzopsis pungens	x		x							x
Koeleria micrantha	x		x		x		x	x		
Carex concinnoides	x	x	x	x					x	x
Stipa richardsonii	x		x		x		x	x	x	x
Festuca saximontana	x		x	x	x				x	
Poa interior	x		x		x				x	x
Agropyron trachycaulum	x		x		x	x	x	x	x	x
Oryzopsis asperifolia		x	x	x					x	x
Poa spp. (juncifolia & pratensis)			x		x	x	x			x
Bromus anomalus					x					x
Hordeum jubatum					x	x				
Stipa spartea					x					
Muhlenbergia richardsonis					x	x	x	x		x

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Juncus balticus					x	x	x	x		x
Carex praegracilis					x	x	x			
Spartina gracilis					x	x	x			
Puccinellia nuttalliana					x	x				
Danthonia intermedia					x					
Agropyron spicatum					x					x
Stipa comata					x					
Stipa occidentalis					x					
Carex petasata					x					
Calamagrostis neglecta						x				
Carex aquatilus						x				
Carex rostata						x				
Beckmannia sp.						x				
Carex sitchensis						x				
Carex atheroides						x				
Alopecurus aequalis						x				
Hordeum brachyantherum						x				
Carex pachystachya						x				

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Deschanpsia caespitosa						x				
Glyceria borealis						x				
Carex lasiocarpa							x			
Carex aurea							x			
Carex parryana							x			
Calamagrostis inexpansa							x			
Carex concinna								x		
Eleocharis sp. ?										
<u>FORBS</u>										
Linnaea borealis	x	x	x	x				x	x	x
Astragalus miser	x	x	x					x	x	x
Epilopium spp.	x	x	x	x	x		x	x	x	x
Anemone multifida	x	x		x	x		x	x	x	x
Achillea millefolium	x	x	x	x	x		x	x	x	x
Fragaria virginiana	x	x	x	x			x		x	x
Solidago spathulata	x	x	x	x				x	x	x
Violoa adunca	x						x	x	x	x

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Pyrola chlorantha	x	x	x					x		
Castilleja miniata	x		x	x					x	x
Aster ciliolatus	x						x	x	x	x
Agoseris spp.	x		x		x				x	x
Senecio spp.	x	x			x		x	x		
Polemonium humile	x		x	x					x	x
Antennaria mycrophylla	x				x			x	x	x
Antennaria neglecta	x		x	x						
Geum triflorum	x				x					
Lithospermum ruderale	x				x				x	x
Heiracium cynoglossydes	x		x	x						
Sedum lanceolatum	x				x					
Gentiana amarella	x				x		x	x	x	x
Erigeron speciosus	x				x					x
Galium boreale	x	x	x	x	x		x	x		x
Aster conspicuous		x	x	x					x	x
Lychnis drummondii		x			x					
Arnica cordifolia				x				x		

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Triglochin maritumum						x				
Potentilla anserina							x			
Solidago canadensis								x		x
Taroxacum officinales					x		x	x	x	x
Artemesia fricida					x					
Potentilla hippiana					x	x	x			
Penstemonprocerus					x					
Cerastium arvense					x			x	x	
Heuchera cylindrica					x					
Zigadenus venenosus					x					
Linum perenne lewisii					x		x			
Aster campestris					x					
Eriogonum heacleoides					x					
Lepidium virginicum					x					
Orthocarpus lutens					x					
Vicia spp.					x		x	x	x	x
Lathyrus ochroleucus					x					
Allium cernum					x		x			x

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Arabis spp.					x					
Ranunculus spp.						x				
Aster eatonii						x				
Polygonum spp.						x				
Hippuris vulgaris						x				
Potentilla pensylvanicus						x				
Potentilla gracilis						x				
Aster pansus						x	x	x		
Smilacina stellata							x	x		x
Sisyrinchium angustifolium							x			
Comandre livida								x		x
Pyrolaceae monensis uniflora								x		
Caryophylaceae Arenaria lateriflora and C. Stellaria longipes							x	x	x	x
Cirsium spp.								x		
Antennaria pulchrima							x	x		x
Thalictrum occidentale							x			x
Arnica chamissonis										x
Antennaria parviflora					x					

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Erigeron loncophyllus							x			
<u>Other Plants</u>										
Cladonia	x	x	x	x				x	x	
Peltigera	x	x	x	x				x	x	
General Fungus	x		x	x	x		x	x	x	
Other lichen	x	x		x	x			x		
Mosses (general)		x		x	x		x	x		
<u>Trees/Shrubs</u>										
Symphoricarpus albus					x					x
Pinus contorta	x	x	x	x	x		x	x	x	x
Pseudotsuga menziesii	x			x					x	
Populus tremuloides	x	x	x	x	x				x	x
Juniperus communis	x	x		x	x				x	x
Shepherdia canadensis	x	x	x	x				x	x	x
Rosa acicularis	x	x	x	x	x		x	x	x	x
Salix spp.	x	x	x				x	x		x
Amelanchier spp.	x			x						x

continued...

Appendix 4 (cont.)	1	2	3	4	5	6	7	8	9	10
Spirea betulifolia	x		x	x	x					
Arctostaphylus uva ursi	x	x	x	x			x	x	x	x
Picea glauca							x	x		x
Ribes spp.										x
Betula glandulosa and pumila							x	x		x
Approximate.....TOTAL SPECIES:	45	26	34	31	58	28	43	44	37	52

APPENDIX 5:

Nutrient analysis on collected sedge material

Results of Nutrient Analysis on Sedge Material collected March 1980.*

Sedge Material	Fibre A.D.F. (% Dry)	Dry Matter (%)	TDN: As Fed	TDN: Dry	Protein: As Fed	Protein: Dry	Calcium: As Fed	Calcium: Dry	Phosphorus: As Fed	Phosphorus: Dry
1. Ungrazed, whole sedge plant (i.e. old material with green material mixed).	45.6	96.8	50	52	3.7	3.78	0.34	0.35	0.07	0.072
2. Selected green material from center of sedge plant (protected by outer growth).	41.0	96.7	55	57	6.4	6.5	0.14	0.14	0.15	0.15

*Soil, Feed, and Tissue-testing Laboratory, 1873 Spall Road, Kelowna, B.C. V1Y 4R2