EARLY WINTER MOUNTAIN CARIBOU BEHAVIOR AND MICRO-HABITAT CHARACTERISTICS IN THE QUESNEL HIGHLAND

Preliminary Results
1995/1996 and 1996 Field Seasons

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EXECUTIVE SUMMARY

Early winter habitat is considered critical to mountain caribou. During this study in the Quesnel Highland and Cariboo Mountains east of Williams Lake, mountain caribou were relocated using radio telemetry. On suitable relocation sites during the period from November-January 1995/1996, and November-December 1996, caribou trails were followed by snow tracking to document habitat characteristics along their foraging path. Trailing sites occurred in four biogeoclimatic units: ICHwk (11 sites), ESSFwc (12 sites), ESSFwk (3 sites) and AT (1 site) and data were analyzed separately for each unit.

The most consistent result was that the habitat attributes measured e.g. diameter at breast height (DBH), lichen class, tree class, snow depths, pole sink depths differed significantly among sites sampled within a biogeoclimatic subzone. There were no clear consistent differences between foraging transects and random transects within these sites. Caribou foraged on a wide variety of foods including lichen on standing trees, lichen on downed trees, lichen on litterfall, shrubs and low ground cover where caribou could crater, or where the forage was exposed.

From the observations described in this report it appears that caribou in early winter are able to forage on a variety of forage types, once they have chosen the general area to forage in. Selection of an area is most likely influenced by factors on a large spatial scale. This conclusion is similar to that suggested by Terry (1994). Factors influencing landscape level habitat selection may include availability of forest cover types, juxtaposition of forested and early seral stage areas (logged), predator avoidance, avoiding harrassment, and differences in snow sinking depths.

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INTRODUCTION

Previous studies have indicated that the ICH biogeoclimatic zone is important to mountain caribou, particularly in the early winter (Seip and Stevenson, 1987; Seip 1992). This zone is also a valuable wood source for the forest industry. More detailed information is needed on stand level habitat requirements of caribou, to manage the interaction between caribou habitat requirements and forest management. Objectives for the project as determined by the British Columbia Ministry of Environment, Lands and Parks (MELP), were as follows:

1) Identify the micro-habitat characteristics of areas used by caribou in the ICH biogeoclimatic zone.

2) Examine early winter foraging strategies with respect to food type, abundance, and snow characteristics.

3) Provide information that will aid biophysical mapping of caribou early winter range.

The working hypothesis was: Caribou are selecting stand level habitats with preferred characteristics in response to foraging strategies.

This report summarizes two winter field seasons of caribou trailing in the Cariboo Mountains and Quesnel Highland (November 1995-January 1996; November-December 1996). This report does not include important food habits data, which are important for comparison with the foraging behavior observations. It is not meant for publication as a journal article or for extensive peer and scientific review, other than for presentation of preliminary results.

I gratefully acknowledge funding provided by Forest Renewal B.C. Project design was provided by the Ministry of Forests (MOF) and MELP. Dr. M. P. Gillingham provided statistical advice and performed some of the statistical analyses. Larry Davis and Sandra Neill supplied the trail observer summaries for their portions. Other field assistance was provided by Craig Sine, Ken Kuenzl and Jason Yochmans. Many thanks go to Julie Steciw and Jim Young of MELP for site locations and logistic support. Thank you also to Harold Armleder, Julie Steciw, John Youds, and Jim Young for their helpful comments on earlier drafts.

STUDY AREA

The study area is located east of Williams Lake in the Cariboo Mountains and Quesnel Highland Ecosections, centered mainly in the area of Quesnel Lake with sites ranging as far south as Crooked Lake and north to Mitchell Lake (Figure 1).

Biogeoclimatic Units included ICHwk (11 sites), ESSFwc (12 sites), ESSFwk (3 sites) and AT (1 site). Conditions in the ICH biogeoclimatic (BEC) zone are characterized by cool wet winters and warm dry summers, and it is a highly productive forest zone, second in Canada only to the CWH zone (Meidinger and Pojar, 1991). Within the study area, this zone occurs on the lower slopes and valley bottoms. The ESSF zone has long, cold snowy winters with snow accumulations from 1-4 m. deep, and a cool short growing season (Meidinger and Pojar, 1991). This zone occurs from mid-slope to high elevations between the ICH and the AT. At its low elevation range, the ESSF forms dense, closed canopy forest, changing to open parkland at high elevations.

Figure 1. Study area map.

Mt. Caribou Behavior
14 April, 1997

METHODS

Sampling Methods

The methods used in this preliminary study were determined by MELP and MOF, and were adapted from Terry (1994). Using radio telemetry, MELP staff located collared caribou and provided their locations in the form of UTM coordinates, written descriptions, and points on 1:50000 scale topographic maps. In the first year we sampled areas that could be reached by helicopter, or by travel overland within a reasonable time. Field crews sampled these sites starting the day after the locations were provided, and continued sampling as long as conditions were acceptable for tracking caribou. In the second year, we gained access to all sites by helicopter. The locations of all sites sampled are provided in Table 1.

Three types of transects were sampled in the first year: 1) The caribou transect (CT) was a 50m long by 2m wide segment along a set of caribou tracks. 2) The random transect (RCT) was a 50m by 2m straight line transect. This transect began 10m from the start point of the CT, following a pre-determined random bearing. 3) The long transect (LT) was a 200m by 2m segment continuing along the caribou trail, immediately after the CT. This set of three transects was called a unit, and units were sampled as many times along a caribou trail as daylight would allow.

In the second year, the 200 meter LT was discontinued, and we changed from two 2-person crews per site, to one 3-person crew per site. Two crew members sampled the CT and RCT, and would also sample a 50 meter intensive transect (IS). The IS transect was identical to the CT, except it was done on a 50 meter segment where foraging had been observed. No random transect was sampled along with the IS transects. CT's and RCT's were located from the start point along a set of caribou tracks, and repeated every 250 meters. The IS was done on each 50 meter segment between CT's where foraging had occurred. Up to five CT/IS transects in a row could be sampled; if five in a row were sampled, then we would follow the caribou trail for 200 meters without sampling, and begin another set of transects.

The third crew member backtracked along the same set of caribou tracks and recorded the presence/absence of foraging on 50 meter segments. If foraging on arboreal lichen occurred, the type and intensity of foraging was recorded, along with the tree species, tree class, DBH and lichen class. If caribou foraged on shrubs, the shrub species was recorded along with a utilization class in the following categories: **1) Trace--1-5% Utilization 2)Light--6-25% 3) Moderate--26-30% 4) Heavy-->50%.** The objective of the trail observer was to determine the frequency of foraging along a trail, and to record any other pertinent observations. Caribou trails were frequently used by more than one caribou, and the trails often split. The protocol all trail observers used to decide which trail to follow was always to decide beforehand which direction the observer would take when the trails split. By deciding in advance of a split, we eliminated bias in our trail selection.

In the first year, once the general area for a site was located on the ground, we began sampling on the first fresh track encountered; one crew would backtrack, and the other would track forward. In year two, we used GPS units to reach approximately the same location provided to us, then we would begin sampling at the nearest set of fresh tracks to this location. At the beginning of each transect, we recorded macro site position, meso site position, aspect, slope, temperature, snow type, and elevation. Snow type followed 6 classes: **1) Dry powder--new snow, light, dry 2) Moderate--recent snow, dry 3)Wet heavy--packs easily, high moisture 4) Powder/crust--subsurface crust 5) Crust/powder--surface crust and 6) Hard/Crusty--little or no penetration.**

Data collected along the CT were tree species, diameter at breast height (DBH), tree life form, log class, lichen class, % Alectoria, caribou activity at each tree, and shrub utilization. Trees included for measurement were those with boles within the 2m. wide path, and trees with overhanging branches within reach of caribou on the path. In 50m segments, #beds, #urinations and #pellet groups were recorded. At 30m from the beginning of the CT, RCT and IS a prism plot and a 5.64m fixed radius plot were established. On the prism plot, tree species, DBH and life form were recorded to estimate basal area of live and dead stems. On the fixed radius plot, tree species, DBH, life form, lichen class and percent Alectoria were recorded. Lichen class estimates followed Armleder et al. (1992). Shrub percent cover by species, was estimated on the fixed radius plots. We included all tree species less than two meters tall as shrubs, and the cover estimate included only shrubs visible above the snow. At every 30m and 50m on the CT, 1X1m plots were used to visually estimate falsebox (<u>Paxistima myrsinites</u>) percent cover. This plot was discontinued for year two as little falsebox was encountered in year one. Every ten meters, snow depth, caribou sinking depth and ski pole sinking depth were measured. Ski pole sinking depth was measured to allow comparisons with the RCT where there were no caribou tracks. A spring balance was used to measure 22.5 kg. while pushing the ski pole into the snow. Data collected along the RCT were the same as the CT, with the exception of caribou sinking depth, shrub utilization and activity. In year two, the IS included the same data collected as the CT.

On the LT, prism plots, fixed radius plots and falsebox plots were not established. Instead, shrub % cover was estimated in 50m segments. Lichen class and snow depths were also not recorded. All other data were collected in the same manner as on the CT and RCT.

Life form classifications followed the wildlife tree classification system. Activities recorded were method of foraging 1)browse and 2)crater; and intensity 1) walk past 2) step toward 3) light trample and 4) heavy trample.

Fecal pellets were collected from every pellet group encountered on the transects. Up to 20 pellets from each pellet group, separated into two groups of ten, were used for composite samples and frozen at the end of the day. The composite samples were consolidated by MELP and sent to the Wildlife Habitat Lab, Washington State University, Pullman, WA.

Analytical Methods

Separate analyses were used for each Biogeoclimatic Subzone. This decision was made *a priori* because the sites in each subzone are ecologically different, and comparing attributes among the three we encountered would mask any true differences or similarities among trailing transects and the random transects. Selection by caribou at the subzone level is a landscape level decision, and is not dealt with here.

Nested analysis of variance was used to analyze diameter at breast height (DBH) of trees in fixed plots, and on the CT, RCT and IS transects. Nesting was required, because all transects after the first CT and RCT cannot be considered independent, and are therefore nested. The lack of independence of all but one set of transects per site limits the comparisons possible with these data.

Paired t-tests were used to compare tree basal area, and numbers of trees per hectare among the three types of transect CT, RCT and IS. Only one observation per variable per site was used, because this test requires that the observations be paired. The sites sampled had different numbers of transects ranging from one to fifteen. To obtain the variable value (DBH or tree numbers) for a site when there was more than one transect of each type in that site, the mean value for that variable from all plots was used in the analysis.

Three-way contingency table analyses were used to compare categorical variables (lichen class and tree class) among transects and among sites. Lichen classes were grouped 0-1, 2, and 3-5 for analyses. There were too few observations in the 0, 4 and 5 category for valid analyses. Tree class was treated similarly, and classified as simply live or dead.

Shrub percent cover on the fixed radius plots was analyzed with one way analysis of variance. To meet the statistical assumptions of ANOVA, only one observation per category per site was permitted. There were only enough data to compare total cover, deciduous and coniferous cover categories among transects and among sites. The percentages were transformed using an arc-sine transformation prior to analysis.

There were too few observations of recently downed trees and foraging behavior on the transects, for valid statistical analysis.

Variables considered landscape level features were also not analyzed because we did not have all of the information required for valid comparisons. Micro habitat characteristics focus on the habitat attributes along the caribou trail, and represent foraging decisions made by caribou after the landscape level decision of 'where to be', has already been made. These analyses will be done at a later date when the required information can be looked at together. Some of the information needed for such analyses are: 1) Radio telemetry locations by season and year 2) Availability of broad landscape parameters such as ecosection, biogeoclimatic zone, forest cover types, elevation bands, and macro sites to name some.

Table 1. Summary of sites sampled.

RESULTS AND DISCUSSION

Shrub Utilization

Of the 384 1X1m falsebox forage plots sampled in year one only 6 had any falsebox. All 6 were from site 2 on Suey Mt. in the ICHwk biogeoclimatic unit. Of these 6 plots, 4 had only trace amounts, 1 plot had 10% cover and 1 plot had 20% cover. These data indicated that the areas caribou were using had very little falsebox. False box plots were not used in the second year of trailing.

Comment:

In 4.8 km. of caribou trailing transects in the first year (50m segments), only four instances of shrub utilization by individual caribou were observed: three on false box (Paxistima myrsinites) and once on willow (Salix spp.) all in the ICHwk. In 19.2 km. of LT's in the first year (200m segments), there were 11 instances of shrub utilization, 10 in the ICHwk and one in the ESSFwk. Of the 10 cases in the ICHwk, 5 were of foraging on false box. In the second year the trail observer data indicate more shrub utilization than the first year data. Please refer to the Trail Observer section for details.

Shrub % Cover

Statistical comparisons among transect types (caribou, random, and intensive) were conducted separately for the ICHwk and ESSFwc biogeoclimatic subzones. The ESSFwk subzone had only two sites and was not analyzed. The first unit of each transect type was used for analysis and an arc sine transformation was performed on the percent shrub cover. There were not enough observations for individual species, so the data were grouped into the broad classes total shrub cover, conifer shrub cover, and deciduous shrub cover. Analysis of variance was used to compare the classes among transect types at each site. No significant differences ($p>.05$) were found among transect types in either subzone using the three methods of calculating shrub cover. Average percent cover for total percent cover in each transect type for the ESSFwc and ICHwk are presented in Table 2.

BEC	Transect Type		
	Caribou	Intensive	Random
ICHwk	14	19	22
ESSFwc	2	3	2

Table 2. Average total percent shrub cover in the ICHwk and ESSFwc for each transect type (November and December 1996 data only).

Rest and Bodily Functions

For beds, urination's and pellet groups, the encounter frequency per kilometer of transect in the first year for each of the categories was 3.75 beds/km.; 13.5 urination's/km. and 6.25 pellet groups/km. over a total of 4.8 km. of trailing. These data on their own provided very little information about how a caribou spends its time. In the absence of specific information on defecation rates, urination rates and bedding frequency, and not knowing how many caribou were using a particular trail, we could not estimate the amount of time in the life of a caribou, these data represent. The small number of beds, pellet groups and urination's do indicate that with the amount of data to collect in the 50m segments, we covered a tiny portion of the distance a representative caribou would travel per day in the early winter. For this reason, in the second year a trail observer followed the caribou trails at each site with the objective of covering a greater distance, and to get a better understanding of foraging frequency. Combining all of the trail observer days together the total distance trailed was 33.9 km. with 124 pellet groups found, for an average of 3.7 pellet groups per km.

Snow Type

Tables 2a and 2b. summarize the 'snow type' data for both years. Of all the transects, only one in both years showed a different snow type among transects within a site. This site was in the Alpine Tundra, and the snow type change reflected the windy conditions of the day and the snow blowing around. Early in the day there was a light powder on top of the hard crust, but as the wind picked up, the powder was blown off leaving just the hard crust.

	Dry Powder		Moderate		Wet Heavy		Powder Crust		Crust Powder	
	CT	RCT	CT	RCT	CT	RCT	CT	RCT	CT	RCT
ICH	0	0	5	5	8	8	7	7	10	10
ESSFwc	40	40	0	0	0	0	17	17	0	0
ESSFwk	10	10	0	0	0	0	0	0	0	0

Table 3a. Summarizes the number of transects in each snow type category for 1995/1996.

	Dry Powder		Moderate		Wet Heavy		Powder Crust		Crust Powder		Hard Crusty	
	CT	RCT	CT	RCT	CT	RCT	CT	RCT	CT	RCT	CT	RCT
ICHwk	1	1	12	5	0	0	6	3	0	0	0	0
ESSFwc	1	1	5	2	0	0	38	12	0	0	0	0
ESSFwk	0	0	10	5	0	0	0	0	0	0	0	0
AT	0	0	0	0	0	0	1	1	1	0	3	1

Table 3b. Summarizes the number of transect in each snow type category for 1996/1997. The Intensive transects are grouped with the Caribou transects.

These data should be used in conjunction with other data such as radio telemetry relocations to describe the landscape, and possibly to aid biophysical mapping. Snow type may have an influence on the landscape level decisions for habitat selection.

Pole Sink Depths

Pole sinking depths were compared between caribou transects and random transects, to assess the ability of the snow pack to support the weight of a caribou. The nested ANOVA using the simplified model **Pole Sink Depth**=Site + Unit(Site) +Type(Site Unit) indicated that for the ICHwk there was a significant difference in pole sink depths only among sites ($p<.05$). ESSFwc produced the same results. For the ESSFwk when analyzing both years' data for caribou and random transects, pole sink depths differed among site and between units ($p<.05$) but not among transect types. For ESSFwk in year two only (only year with all three types of transect), pole sink depths differed only among sites ($p<.05$). Table 4 summarizes the mean pole sinking depths by subzone for each year.

Year	ICHwk	ESSFwc	ESSFwk
1995/1996	17.1 n=58	28.6 n=58	37.5 n=12
1996	18.6 n=101	29.7 n=118	38.9 n=30

Table 4. Mean pole sinking depths in centimeters, for 1995/96 and 1996.

For the BEC units we are looking at, the snow type for each site on a particular day did not differ among units and transects. Snow type directly influences the sinking depths so if the snow type remains constant, the sinking depths should not differ significantly among transects. The data support this conclusion.

Caribou Sink Depths

Comparing biogeoclimatic subzones, caribou sinking depths differed significantly among all subzones in winter 1996 ($P<.05$); and differed between ICHwk and ESSFwc in winter 1995/1996 ($P<.05$). There were too few data in 1996 for ESSFwk to test with the other subzones. Table 5 summarizes the mean sinking depths by subzone for each year.

Year	ICHwk	ESSFwc	ESSFwk
1995/1996	24.9 n=29	32.4 n=29	39.7 n=6
1996	23.0 n=47	27.3 n=81	33.8 n=47

Table 5. Mean caribou sinking depths in centimeters, for 1995/1996 and 1996.

There is a clear trend indicating that ICHwk has the lowest sinking depth, with ESSFwc the next lowest while ESSFwk has the deepest sinking depth. These data indicate that sinking depth may be an important factor for caribou habitat selection on a large spatial scale.

Before any further conclusions can be reached, sinking depths need to be analyzed with the radio telemetry data and forest cover information. The purpose of such analysis would be to determine habitat availability when sinking depths were sampled; and to determine if the same radio collared caribou are using the ICH and ESSF respectively, or whether caribou are moving from one BEC unit to another, possibly to minimize sinking depth. The sequence of movements relative to availablity of BEC units is important for management. Are the caribou that use the ESSF where sinking depths are greater, staying in the ESSF because they have no ICH habitat available to them, possibly due to logging? Are the caribou in the ICH staying there for the early winter, or are they moving back and forth between BEC units?

Snow Depths

The data reported here are for winter 1996 only. A nested ANOVA using the simplified model **Snow Depth**=Site + Type(Site) for ICHwk and ESSFwc, indicated significant differences among sites and among types within sites (p<.05). For the ESSFwk the model **Snow Depth**=Site + Unit(Site) + Type (Unit Site) indicated significant differences among sites and among types within site and unit (p<.05). There were no significant differences among unit within site (p>.05). It is not surprising that snow depths would differ among sites, as they reflect snow accumulation over time and in different locations during the winter. Upon inspecting the means for each transect type for all BEC units there are no clear trends, but they do indicate that snow depths are quite variable within a site. The differences found are probably a result of the variable snow depths, influenced by features such as tree canopy or lack of it, wind exposure, sun exposure or other modifying influences. The data are inconclusive as to whether or not caribou are selecting paths over particular snow depths relative to that found at random.

Tree Diameters

Diameters for all trees >10 cm. DBH within 1m. on each side of the transects were estimated to the nearest 10 cm., and the mid-points of the diameter ranges recorded. For the transects, the nested ANOVA with the simplified model **DBH**=Site + Unit(Site) +Type(Site Unit) indicated that for the ICHwk there was a significant difference in tree diameter among sites, among units within site and among transect types within units and sites (p<.05). For the ESSFwc units, there was a significant difference among sites, and among units within sites (p<.05), but not among transects within site and unit (p>.05). For the ESSFwk results were similar to those of ESSFwc where there was a significant difference among sites, and among units within sites (p<.05), but not among transects within site and unit (p>.05).

Fixed plots were analyzed for DBH using the same ANOVA model. For the ICHwk and the ESSFwk, results were the same for both the transects and fixed radius plots. For the ESSFwc the results for the plots differed from the transects. Site, and unit within site, and type within unit and site showed a significant difference (p<.05) i.e. all levels of the model showed a significant difference. For comparison of relative diameters, please refer to Table 6.

	ICHwk		ESSFwc		ESSFwk	
Plot Type	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Caribou	30.82	20.95	21.98	10.27	28.54	14.41
Intensive	38.60	28.13	21.36	9.84	29.20	12.95
Random	32.83	23.11	21.48	10.09	28.68	12.33

Table 6. Mean tree diameters for BEC subzones, fixed plots winter 1996.

Consistent among all BEC sub-zones and between transects and fixed plots, is that within subzones the sites are significantly different. As mentioned previously, site selection (use) is a landscape level decision that needs to be analyzed against the availability. The main question we are asking is given that the caribou are here, does DBH on the transects they are using differ from random. For the ICHwk, caribou, intensive and random transects differ from one another, but in the other two zones they do not. The central question is why? One potential explanation centers around the variety of foraging opportunities in the ICHwk. The variety of available forage types is greater in the ICHwk than in the ESSF subzones, and this variety allows caribou to feed in many different ways and on different types of forage, including lichen on standing trees, shrubs, litter, lichen on downed trees, and on low ground cover where they can crater. Results from the Trail Observers corroborates this view i.e. in the ESSF subzones, most foraging is on lichen. In the ICHwk caribou obtain a greater proportion of their food from other sources. This switching from one forage type to another may be behind the difference in DBH for transect type. In other words, caribou are not as obligated to obtain their food from trees as in the ESSF, so many of the trees in their foraging path are incidental to foraging whereas the trees in the ESSF subzones are the target for foraging. Along with this different foraging strategy among subzones, is the relative uniformity of DBH within a site in the ESSF, while the stands within sites in the ICHwk have a far greater range of tree diameters. Caribou encountering vastly different tree diameters in a relatively short distance could explain transect differences in the ICH, and relatively uniform tree diameters within a site in the ESSF subzones where transects do not exhibit a significant difference, could explain any transect 'type' differences.

Tree Density

The paired t-tests for the ICHwk and ESSFwc BEC subzones indicated that there were no significant differences between caribou and random transects ($p>.05$) or between intensive and random transects ($p>.05$) for the number of stems/hectare of live or dead trees within the fixed radius plots. With only three sites sampled for the ESSFwk, there were not enough data for valid comparisons. Table 7 summarizes the mean tree densities for each plot type by BEC subzone.

Plot Type	ICHwk		ESSFwc	
	Live	Dead	Live	Dead
Caribou	598	67	547	149
Intensive	469	68	772	250
Random	499	51	569	100

Table 7. Mean numbers of trees per hectare for the ICHwk and ESSFwc (1996 field season).

Tree Basal Area

The paired t-tests for the ICHwk and ESSFwc BEC subzone indicated that there were no significant differences between caribou and random transects (p>.05) or between intensive and random transects (p>.05) for the basal area of live or dead trees. With only three sites sampled for the ESSFwk, there were not enough data for valid comparisons. Table 8 summarizes the mean basal area for each plot type by BEC subzone.

Plot Type	ICHwk		ESSFwc	
	Live	Dead	Live	Dead
Caribou	56	5	29	6
Intensive	62	7	29	9
Random	61	8	26	5

Table 8. Mean basal area (m^2) per hectare for the ICHwk and ESSFwc (1996 field season).

Tree Vigor

Three way contingency table analyses were conducted for tree vigor class comparing transect types among sites. In all cases, even with grouping tree class into only two categories (live and dead), there were not enough observations to make valid multivariate comparisons i.e. there were cells with too few observations, or rows or columns with zeros. The only valid multi-way comparisons were between caribou and random transects among sites in the ESSFwk. Those results indicated a significant difference (p<.05) between transect types and sites. Chi-square tests were then performed comparing transect types with tree class using all data from both years. The results indicated no significant differences among caribou, intensive and random transects (p>.05). Tree class differed by site, but not by transect type for the ESSFwk.

For the ICHwk and the ESSFwc, Chi-square tests were done in the same manner as for ESSFwk. Reporting on the ICHwk first, there were significant differences only between caribou and random transects ($p<.05$). On inspection of the data (Table 9), there were more dead trees than expected for the random transect (16% of trees were dead) and fewer than expected for the caribou transect (11% of trees were dead). For the ESSFwc, only the caribou and intensive transects differed significantly ($p<.05$). On inspection of the frequency table (Table 9), there were more dead trees than expected for the caribou transect (20% of trees were dead) and fewer than expected for the intensive transect (14% of trees were dead).

Transect Type	**Frequencies**	**ICHwk**		**ESSFwc**		**ESSFwk**	
		Live	Dead	Live	Dead	Live	Dead
Caribou	Observed	363	44	640	159	154	17
Caribou	Expected	353	54	659	140	155	16
Intensive	Observed	113	18	542	91	114	7
Intensive	Expected	114	17	522	111	109	11
Random	Observed	271	52	459	99	101	14
Random	Expected	280	43	460	98	104	11
Totals	Observed	747	114	1641	349	369	38

Table 9. Observed and expected frequencies of live and dead trees found along the 50 meter transects, for each transect type. Data are from both years of sampling.

It is not possible to know at this point, if the differences reported are merely reflections of site to site differences. I suspect that they are.

Tree Species

It is clear that in the ESSFwc, caribou are encountering balsam at a significant rate, and that in the ICHwk, they are encountering hemlock at a significant rate (Table 10). I am hesitant to draw conclusions from these data, without the benefit of use availability information from the caribou radio relocation's. These sets of data should be analyzed together before drawing conclusions. The question of whether these caribou are living in stands which have higher proportions of balsam and hemlock respectively; or whether they are selecting these species over others because they prefer them or need them; or whether caribou are choosing areas for other reasons such as predator avoidance, or avoidance of humans on snowmobiles, are important questions for forest management, that cannot be answered by these data alone.

BEC	Tree Species						
	Hemlock	**Cedar**	**Balsam**	**Spruce**	**Pine**	**Other**	**Totals**
ICHwk	322	182	53	32	5	32	626
ESSFwc	6	0	923	165	8	37	1139
ESSFwk	4	4	197	75	13	0	293
Totals	332	186	1173	272	26	69	2058

Table 10. Species of trees encountered on caribou and intensive transects for both years of sampling.

Lichen Class

Three way contingency table analyses were conducted comparing lichen class by transect among sites. In all cases, even with grouping lichen class into only three categories, there were not enough observations to make valid multivariate comparisons of lichen class i.e. there were cells with too few observations, or rows or columns with zeros. The only valid multi-way comparisons were between caribou and random transects among sites in the ESSFwk. Those results indicated a significant association ($p<.05$) between transect type and site. Chi-square tests were then performed comparing transect types with lichen class using all data from both years. The results indicated significant differences ($p<.05$) among all transects. The frequency table (Table 11) shows that lichen class 2 is most common, and is also more frequently encountered on the caribou and intensive transects, than on the random transects. Caribou were encountering lichen class 2 trees more often than we found on the random transects, but they were also encountering lichen class 3-5 trees less frequently than random.

Transect Type	**Frequencies**	**ICHwk**			**ESSFwc**			**ESSFwk**		
		0-1	2	3-5	0-1	2	3-5	0-1	2	3-5
Caribou	Observed	215	182	32	92	485	224	41	98	34
Caribou	Expected	245	155	29	131	474	196	53	95	26
Intensive	Observed	105	18	0	140	376	122	36	80	7
Intensive	Expected	70	44	8	105	378	156	37	67	18
Random	Observed	170	110	26	95	320	141	47	46	20
Random	Expected	175	111	21	91	329	136	34	62	17
Totals	Observed	490	310	58	327	1181	487	124	224	61

Table 11. Observed and expected frequencies of lichen classes for each transect type. Data are from both years of sampling.

For the ICHwk and ESSFwc, Chi-square tests were also done in the same manner as it was for the ESSFwk. Reporting first on the ICHwk, there were significant differences between caribou and intensive transects, and between intensive and random transects ($p<.05$). There was no significant difference between caribou and random transects ($p>.05$). On inspection of the frequency table, we find that on intensive transects, 85% of the observations are in the 0-1 lichen class while on the other two transects they are close to 50%. This observation corroborates the previous idea, that with a variety of forage items available, lichen bearing trees may be less important and are not as actively sought out for forage. An important question that needs to be answered here is, what relationship if any, is there between palatable shrubs and ground forage, and lichen availability i.e. Is there an inverse relationship between shrub availability and lichen availability in the ICHwk?

For the ESSFwc, as was the case with the ESSFwk there were significant differences among all transects ($p<.05$), but no major trends are apparent. For the caribou transect 88% of observations are in lichen classes 2-5; for random transects 82% are in lichen classes 2-5; and for intensive transects 78% are in lichen classes 2-5. There is only a 3% difference among all transects for lichen class 2, the most frequently observed class. Even though there are statistically significant differences among the transects, these differences do not seem to be biologically significant particularly since in the ESSFwc most foraging is on lichen, yet the intensive transects show caribou encountering the lower lichen class trees at a higher rate than the other transects.

TRAIL OBSERVERS

Site 101. McKusky Creek. ICHwk. Greg Ashcroft, Trail Observer.

After falling through the ice immediately after leaving the helicopter, then drying off it took approximately 45 minutes to reach the trailing site. There was only time left for 250 meters of trailing before I had to return to the helicopter pick up site. Two of the five segments had cratering with light trample, but it was not possible to be sure of foraging. It looked like they were foraging on moss or bunchberry. The trail was a group of caribou of indeterminate size, and they had spent 75 of the 250 meters trailing, sliding down a 75% slope.

Site 102: Mitchell R. ICHwk. Larry Davis, Trail Observer.

Most of caribou activity on this site appeared to be searching with much of the area being covered more than once. In 1900 m of caribou trail, only 9 segments had foraging for a 24% foraging rate (percent of segments with foraging). Arboreal lichens were fed on in 44% of the observations, and cedar was the predominant substrate. The remaining foraging occurred on shrubs with red elderberry (Sambucus racemosa) being most commonly used. On individual food items, very little feeding occurred even when an abundance of forage was encountered: a lichen class 3 cedar had a lot of lichen available when the caribou left; and only a few stems were browsed in a patch of Oregon grape.

Site 103. Mt. Brew. ESSFwc. Greg Ashcroft, Trail Observer.

In 3000 meters of trailing, 24 segments had foraging for a 40% foraging rate. Foraging was mainly on arboreal lichen (Bryoria sp); 39 of 43 instances of foraging recorded (91% of observations) was on arboreal lichen, with three observations of foraging on shrubs. Lichen was obtained predominantly from balsam 35 cm. DBH or less. Shrubs foraged on were severely damaged and difficult to identify. Other than the heavily damaged shrubs, there was nothing unusual in their behavior. The caribou spent their time meandering through the forested area, feeding occasionally on lichen, primarily from balsam trees i.e. it was primarily a balsam stand. The tracks I followed were traveled on by more than one caribou, so I kept changing from trail to trail as animals split off then joined up again on the same path.

Site 104: Black Bear Creek. ESSFwc. Larry Davis, Trail Observer.

Caribou were trailed a total of 1800m with foraging occurring in 14 segments (39%). All feeding occurred on arboreal lichen (100% of foraging observations), and balsam was the predominant substrate. Feeding intensity did not change in relation to lichen class. In the majority of non-feeding segments, the caribou appeared to be traveling with no interest in feeding. Behavior while in travel mode was different than when in the feeding area. Travel was direct with little wandering as they moved up from the valley bottom to the feeding area on the upper slope of the ridge. As they neared the feeding area, more wandering and splitting occurred. The lichen class of trees in the feeding area ranged from 2-5. Lichen biomass did not seem to influence feeding intensity in the foraging area, with the highest feeding intensity ratings (light trample) occurring on lichen class 2 & 3 trees.

Site 105. Mt. Brew. ESSFwc. Greg Ashcroft, Trail Observer.

In 1850 meters of trailing, caribou foraged in 30 segments for a foraging rate of 81%. The caribou foraged extensively on cow parsnip (22% of observations) and Bryoria (74% of observations). Approximately half of the trees caribou obtained lichen from were balsam and half were spruce. Foraging also occurred in a few instances on black twinberry, rose spp., highbush cranberry, crowberry and arrow leafed groundsell. Foraging on cow parsnip consisted of eating the seed head off of the top of the dried plants. The heads were either sticking just out of the snow or were slightly covered by snow, so they were browsed directly or the caribou cratered slightly, presumably with their snouts, then browsed. The caribou appeared to be selecting paths toward cow parsnip in the open areas it occurred in, and toward lichen bearing trees both in open areas and in more densely forested area. The caribou were also cratering in open ‘seepage’ areas, but I could not determine what was being eaten, except that they appeared to be eating forbs. Once again I was following a group of caribou and was frequently splitting from one trail to another.

Site 106: Mitchell Lake. ESSFwc. Larry Davis, Trail Observer.

Caribou were trailed for 1900m with foraging occurring in 18 segments (47%). Arboreal lichen was fed on 16 times (53% of the observations). Of this, balsam was the substrate 50% of the time and hemlock 38% of the time. Lichen class did not influence feeding intensity. The majority of remaining foraging occurred on bunchberry (14 observations), with some falsebox also being eaten. The caribou at this site centered their activity around a fallen snag. Caribou trails ranged out several hundred meters from this spot then the caribou worked their way back to the snag and fed again. The only case of heavy trampling occurred at this log. It appears that a male and female were using this area from the rutting behavior exhibited. The caribou also made extensive use of the snow craters at the base of trees. The shallow snow in these locations allowed access to bunchberry which was fed on by stripping the leaves off the stem. In one section of trail, the caribou went from tree to tree for 400-500m searching out this food source.

Site 107. Bill Miner Creek. ESSFwc. Greg Ashcroft, Trail Observer.

We were dropped off on a landing in a recent clear cut, and it was snowing slightly. The only recent tracks were located just inside the forest at the edge of the cut block. The plot sampling crew forward tracked and I back tracked which led me out into the cut block. By the time we began tracking it was blowing and snowing heavily. I tracked for 150 meters, before the trail was completely obliterated with drifted snow. I observed one instance of foraging on lichen (Bryoria) from a balsam top in the clear-cut. The plot sampling crew was able to sample only one CT and one RCT before their trail was obliterated. Drifting snow obliterated tracks both inside the forest area and in the openings, so no further trailing was possible.

Site 108: Wasko Lake. ESSFwc. Larry Davis, Trail Observer.

Caribou were trailed for 2250m with feeding occurring in 31 segments (69%). All foraging occurred on arboreal lichen (100% of observations), and balsam was the substrate in 60 out of 81 observations (74%). Size classes range from 15 to 45cm, with 25cm being most common. The only cases of heavy trampling occurred on downed trees (3 out of 4 feeding opportunities on logs). Feeding intensity was highest on class 4 trees (moderate in 83% of encounters) and decreased with lichen class (class 2: moderate in 24% of encounters; class 3: moderate in 13% of encounters). Caribou would seldom travel more than 50m without feeding at this site.

Site 109. Goose Peak. ESSFwc. Greg Ashcroft, Trail Observer.

In 2250 meters of trailing, caribou foraged in 21 segments for a foraging rate of 46%. They foraged mainly on Bryoria (89% of observations), with a few instances of foraging on Rhododendron, Black Twinberry and Highbush Cranberry (11% for all three shrubs). Free water was encountered at one spot and caribou appeared to drink there. For three of the segments, caribou had been leaping downhill apparently startled by something. Of all instances of lichen foraging observed, 27% were of litter fall so caribou at this site were obtaining a substantial amount of lichen this way. The bulk of their lichen foraging was on trees, almost exclusively balsam 25cm. DBH or less.

Site 110. Browntop Mtn. ESSFwk. Sandra Neill, Trail Observer.

Trailing commenced by following 3-4 animals through a clear-cut to the flooded foreshore of a small lake. This area was typified by small dead spruce (5-15 cm DBH), most standing, a few in the form of logs. The caribou appeared to spend considerable time wandering and feeding from these trees. Although the tree lichen classes were 1 and 2, the amount of lichen was proportionately large for such small trees. On one occasion there was some cratering at the base of a tree. I was unable to ascertain what the animal was feeding upon, but there were a number of sedge plants exposed and damaged. Plants were damaged from feeding or cratering or both; possibly the fecal analysis will show what was being eaten at this site.

The animals then traveled across the lake, occasionally feeding on arboreal lichen from small dead spruce along the shore. They then proceeded up through the clear-cut and along an old logging road, the latter half of which was plowed. They walked along the roads for more than a kilometer, then traveled a short distance through a clear-cut. They then entered a wet timbered area, and up into an adjacent upland forested area of spruce and balsam (mature leave strip between blocks), back onto a road then into a clear-cut (about 10 year old with 1-3m pine). During this travel (1.9 km) period, there was no feeding, no fecal pellets found, no urination's nor beds.

For the next 100m, the animals we were following, had heavily damaged a few willow bushes, 3 small pine trees and one spruce in a "rub tree" fashion. Then they resumed just traveling for another 750m where they left the clear-cut, entered mature timber and started feeding on arboreal lichen mostly from balsam trees and the occasional spruce. Any recent blowdown that the animals encountered was heavily browsed.

In total, 3750 meters were covered with foraging in 18 segments (24%). Caribou primarily fed on arboreal lichen (94% of observations), although willow, alder, cow parsnip, elderberry, vaccinium and aspen were all present without the need for cratering. The most unusual observation was the heavy damage inflicted by caribou on a few trees, presumably by rubbing or chewing.

Site 111. Ladies Creek. ESSFwc/AT. Greg Ashcroft, Trail Observer.

We were dropped off on the top of an open rocky ridge in the Alpine, above the UTM location provided. We searched the area around the UTM location, but could not find tracks there. We had encountered tracks on the way there, but our objective was to find tracks as close as possible to the location provided. After about an hour of floundering in deep powder on steep slopes, we elected to follow the tracks we had encountered earlier. The plot crew forward tracked while I backtracked. The plot sampling ended up being entirely in the alpine.

In 550 meters of trailing, foraging occurred in seven segments for a foraging rate of 64%. Foraging occurred on Bryoria (75% of observations) and possibly on crowberry (25% of observations), but it was not possible to determine with confidence that they had foraged on it. The area I was trailing in was a south facing slope, characterized mainly by scattered and stunted balsam and spruce. The group of caribou had been meandering throughout the treed area foraging and had bedded there. I ended the transect at 550 meters because my tracks kept doubling back into my trailing transect and I could no longer find a clear trail. I then back tracked about 250 meters and started a new trail, but this trail led to the tracks followed by the other sampling crew.

By early afternoon blowing snow driven by high winds had obliterated the trails so sampling ended. We were concerned about our safety and after waiting for the weather to clear for about an hour, we began heading downhill because we knew we had to walk out. When the helicopter arrived in the area we had radio contact with the pilot, and it was clear he could not pick us up. We walked downhill and arrived at a road just as it got dark.

Site 112. Sellars Creek. ESSFwk. Sandra Neill, Trail Observer.

The day began with the caribou foraging on arboreal lichen primarily from balsam trees, for 25 observations in a row. The caribou then switched to a combination of arboreal lichen and cratering for ground based feed types. The cratering and associated foraging caused so much damage to plants that I was not able with 100% confidence, to identify preferred plants or their utilization levels. *Cornus canadensis* and *Rubus pedatus* were present at each cratering site, so I assumed that they were the primary plants being browsed. (Pellet analysis may prove/disprove this observation.) From these data 53% of foraging was on arboreal lichen, and 47% was on shrubs.

Of interest, was that all cratering occurred under the crown of trees, all of which were balsam. Cratering ranged from small scrapes to very extensive excavations over a large area (10m by 3m). One time I observed a spot where a caribou had cratered on top of a well decayed log. It appeared deliberate, but as seen at other cratering sites it was difficult to determine the forage species. I tried cratering (by hand) under a balsam once as a comparison, but only ended up damaging any plants that were exposed. I could see no real difference in damage done by my cratering alone, compared to cratering and presumably foraging by caribou.

Due to the extensive foraging and inclement weather (the helicopter came early), we ended trailing at 2400 m. Of the 48 segments, 43 had foraging for a rate of 90%.

Site 113. Watt Creek. ICHwk. Greg Ashcroft, Trail Observer.

In 1950 meters of trailing, foraging occurred in 15 segments, for a foraging rate of 39%. The caribou were foraging on a combination of lichen from trees, litter fall and to a minor extent on shrubs. Significant amounts of Alectoria were present and much of the foraging on lichen that could be identified was on Alectoria, but there were many cases where I could not identify whether foraging was on Alectoria or Bryoria. This site was the only one where I observed there was significant availability and amounts of foraging on downed logs. Of 19 instances of lichen foraging recorded, 9 were on recently downed trees or large pieces of trees (47%), 6 were on litter fall (32%), and 4 were on standing trees (21%). As with all other cases of following a group of caribou, trails kept splitting and coming together and meandering throughout the area in use. At the last segment sampled, I ran out of trails that I had not already walked on, and since it was near the time for pick up, there was not time to find a new trailing area.

Site 114: Little River. ICHwk. Larry Davis, Trail Observer.

Caribou were trailed for 2750m with foraging occurring in 24 segments (43%). Arboreal lichen was fed on in 71 out of 98 observations (72%). Pine was the predominant substrate, and feeding intensity was rarely greater than low. Caribou at this site, made extensive use of a wetland for feeding. The snow depth was approximately 1m in the open; however, the large number of craters and heavy trampling in this area indicates that the foods they were obtaining were worth the effort expended. I eventually found a pair of tracks leading into the area and followed them up the valley bottom. In this section of the trail, caribou behavior changed. Travel was direct with very little feeding sign. Caribou made use of shallow snow in tree basins by going from tree to tree often ducking under thick branches to make use of the shallow snow conditions. This probably saved a lot of energy since the trees were in clumps and the snow was deep in the open areas between. The caribou trail eventually led uphill onto a south facing slope with thicker tree cover where the behavior changed back to a feeding mode. Here the feeding switched between arboreal lichen and falsebox. The feeding intensity on falsebox was moderate or high much of the time. The lichen class of trees in this area was never greater than three and only a few instances of light trampling were observed.

Site 115. Franks Creek. ICHwk. Greg Ashcroft, Trail Observer.

In 1800 meters of trailing, foraging occurred on 14 segments, for a foraging rate of 39%. Twelve of the segments were wholly or partly on the beach beside Quesnel Lake. Foraging on the lake shore occurred on rock outcrops where caribou ate either lichen or moss or both; on lichen from standing trees at the shore, and lichen on downed trees at the shore. Two of the downed trees caribou fed on at the shore had been cut down, while the others had fallen over. Lichen from litter fall inside the forest, and bunchberry were also significant forage items. Moss may have been fed on at the bunchberry sites, but it was difficult to determine. The tracking conditions on some of the trails in the forest were difficult as they had about 1 cm. of snow in them. It was difficult to detect foraging on these trails, as most of the foraging under the dense canopy appeared to be focused on the ground.

Once away from the edge of the shore and the influence of increased light conditions was lost, the stand was characterized by large cedar and hemlock, with little understory. There was very little lichen on these large trees and lichen foraging on these large trees appeared to be minimal. Most of the foraging was on ground cover or litter fall under the dense forest canopy, and on lichen at the shore where they were more available. A few large diameter downed trees were encountered and foraging was observed, but the lichen amounts on these trees was small, at lichen class 1. In total, foraging occurred on lichen 66% of observations; on lichen/moss 18% of observations; and bunchberry/moss 16% of observations.

While trailing along the shore of Quesnel Lake, two caribou were observed on the beach at the helicopter landing site. They appeared to be a cow and a calf. Thirteen minutes later, they were swimming in the lake heading toward the far shore. It was windy and the water was quite choppy. They seemed to make little progress toward the opposite shore. Nine minutes after I first observed them in the water, they were back on the shore 500 meters southwest of the landing spot where I had originally seen them.

After 1800 meters of trailing, the tracks I was following at the time showed that the caribou had been startled. I believe it was our presence that startled the animal (s), so I discontinued that trail. I was unable to find another trail that was not already tracked on by the plot sampling crew, before the end of the day.

Site 116: Bill Miner Ck. ESSFwc. Larry Davis, Trail Observer.

Caribou were trailed for 3000m with feeding occurring in 46 segments (77%). Caribou at this site fed only on lichen, and large balsam (35-45cm) appears to be the predominant substrate. Heavy trampling was observed at two of three logs. Tracks around the logs indicated that several different individuals foraged there. The lichen class of trees at this site was mainly 2-3, and the intensity of feeding did not seem to relate to the availability of lichen. The animals moved slowly up-slope by wandering in circles that gradually moved them in that direction and were never observed in travel mode.

Trail Observer Summary

Some key observations from the trail observer accounts are summarized as follows:

1. In early winter, caribou feed on lichen and ground forage in the ESSFwc, but as the snow depths increased there was less opportunity to forage on items other than arboreal lichen.
2. Clear cuts appear to offer little or no foraging opportunity, but caribou will move through them. Even though willlow, alder, cow parsnip, elderberry, vaccinium and aspen were available without cratering in a clear cut, the caribou did not feed. After leaving the opening, they fed on arboreal lichen in mature forest adjacent to the clear cut.
3. In the ICHwk, caribou often cratered to obtain ground forage. When the snow depths increased, they cratered at the base of trees where the snow was shallower.
4. When cratering, bunchberry appeared to be a favored food item.

COMMENTS AND RECOMMENDATIONS

The most consistent observation is that the habitat attributes measured (DBH, lichen class, tree class, pole sink depths) differ significantly among sites. This leads to the conclusion that sites are not chosen for their predictability among sites, or for a single preferred attribute. Rather, caribou seem to be selecting sites for other reasons, and the selection of the site overrides the effect of the particular attributes we have measured. From this study, caribou appeared to forage on many types of plants, and to switch from plant type to type depending on availability. Caribou need to have some type of palatable and nutritious food available, but it does not appear to matter if the foods available are shrubs, or lichen or a combination of types on a micro site level. When in early winter habitats caribou appear opportunistic. Within a range of palatable forage types, they feed on whatever items are available. The food habits analyses are expected to provide further insight into the type of food caribou were eating. At the landscape scale, it appears that they utilize a variety of forage types across the entire landscape. The differences among sites and among BEC units reflects this idea.

Caribou probably use broad foraging areas in response to factors other than foraging such as predator avoidance, avoiding harassment, changing weather conditions and changing snow conditions. Analysis of landscape level attributes is required to shed light on factors affecting site selection, and such analysis is needed to put the results of the caribou trailing in context. One analysis that could be done, is to subdivide all radio relocation's by BEC, and to sample habitat attributes of a statistically valid portion of those relocation's with a view to comparing those attributes with random samples of the same BEC. These results should then be compared with the results from trailing. If caribou are selecting sites that are different from random, then the data could be used to predict the valuable site types. If they are not selecting sites with different attributes than random, then they may be selecting for very broad ecological attributes such as snow conditions, avoidance of predation etc.

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