Assessment of potential for mountain caribou habitat recovery (recruitment) in Landscape Unit K-18, Kootenay Lake Forest District

Prepared for Meadow Creek Cedar Ltd.
Forest Investment Account

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Abstract

This project utilized field sampling and reconnaissance to assess the present and potential future condition of mature (age class 5, 6, and 7) stands in Landscape Unit K-18 as habitat for mountain caribou. Greater present suitability than expected was observed in most of these stands, and future suitability for caribou is projected to vary between stand types. This is illustrated by a set of time-series maps driven by combined field findings and GIS data that show present conditions and hypothetical future conditions at 30, 60 and 120 yr. intervals. The implications emerging from this exercise are discussed, and suggested next steps are recommended.

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Introduction

The recognition that habitat for mountain caribou needs to be planned and managed over extensive landscapes and long time periods to be successful is implied by most recent and historic research findings. Examples include the current hypotheses that small, isolated mountain caribou herds in B.C. may be headed for extinction (Wittmer et al. 2005), in the measured evidence that short-term avoidance of predation is greater in large, unfragmented forest matrixes (Apps et al. 2007), and by studies indicating the critical survival value of calving in a broadly dispersed manner (Bergerud et al. 1984). The fact that older forests are a key component of landscapes for caribou has been recognized for several decades (Scott and Servheen 1985), with field research findings from the 1980's – to 2000's confirming the stand-level behavioral reasons for this: the best winter stands are characterized by abundant and available hair lichens, *Bryoria* spp. and *Alectoria sarmentosa*, that are obtained by caribou from whole tree blowdown and branch breakage as well as through direct feeding from branches and trunks (Herbison 1988, Rominger and Oldemeyer 1988, Antifeau 1989, McLellan et al. 1994, Rominger 1995, Kinley et al. 2003, Serrouya et al. 2007). These qualities are normally associated with older forests, although the actual age of peak lichen production and availability specific to forest type has not been well-studied (Norquay 2000).

In the Kootenay Region, the assumption that age class 8 and 9 forests (> 140 yr) represents suitable winter habitat for caribou has been accepted without question and incorporated in timber harvest guidelines aimed at limiting the impacts on those age classes. The first set of guidelines was the Ministry of Environment Wildlife-Logging Guidelines (unpubl. 1989), and the current legal framework is the Kootenay Boundary Higher Level Plan variance 04 (KBHLPO4; Abbott 2004). All guidelines past and present prescribe percentages of age class 8 and 9 in delineated landscape areas (now Landscape Units or LUs), with the intention of protecting early- and late-winter habitat. Less well-addressed are the other age classes (an obviously necessary part of a long-term strategy), and the reality that suitable habitat will inevitably shift over time. Recent reminders of the need for a broader, more flexible paradigm for caribou habitat management have been the Skinner-Madden fire in 2003 and the Hamill Creek fire in 2007 which resulted in extensive old-growth losses within "protected" areas.

An interest in this broader paradigm led to the present project, along with the Meadow Creek Cedar's expressed desire to proactively meet KBHLPO4[1] requirements for caribou habitat recruitment. Under KBHLPO4, in LUs with "deficits" of old growth there is a requirement to recruit equivalent hectares from younger age classes, with priority on the oldest available. Landscape Unit K-18 has a deficit of old growth for caribou of 1527 ha in the ESSFwc4 biogeoclimatic variant (BEC), and 2031 ha in combined ICHmw2 and ICHwk1 BECs, as calculated by Niblett (2006) for the Ministry of Forests and Range Kootenay Lake District using the government digital database.

The purpose of this project has been to assess the future potential for caribou habitat recovery (recruitment) in LU K-18 and surroundings through the field evaluation of present conditions (supplemented by GIS map products and analyses) and, in doing so, to provide guidance for retention and harvesting in the existing age class 5, 6, and 7 stands.

A more general, additional goal has been to contribute to the development of a longer-term recruitment strategy over a broader landscape area.

Objectives

Specific objectives have been to

- Provide appropriate GIS[1] analyses of VRI[2] and TRIM[3] databases illustrating the available present age classes and slope classes in LU K-18.
- Map and rank present suitability for caribou in age classes 5, 6, and 7, and probable future suitability based on field sampling and reconnaissance.
- Experiment with creating GIS-aided time-series map projections ("snapshots in time"), built on the above, as a tool for planning in a spatially dynamic manner over long time periods.
- Identify the most valuable stands, zones, and site types for recruitment, i.e., for retention, or stand-tending efforts out of a synthesis of all of the above.
- Identify important information needs and recommended next steps in planning for future caribou habitat.

Project Location

Landscape Unit K-18 lies in the east-central portion of the Central Selkirk caribou range, at the north end of the Kootenay Lake Forest District as shown on Map 1, Appendix A.

Methods

Pre-fieldwork map overviews and GIS analyses

The first stages of the project were designed to obtain and portray landscape-level perspectives at several scales prior to stand-level assessments: first a very broad (regional) scale, then a Landscape Unit scale, followed by an even smaller planning subunit scale, and, during field reconnaissance, an even smaller-scale, approximating 300- 500 hectares.

To view Landscape Unit K-18 in the context of the broad regional landscape the project utilized a themed age class map for the West Kootenay – Slocan portion of the Nelson Region (L. DeGroot, Ministry of Environment, unpubl. map). It was not feasible to include this map with the present report due to technical limitations but it is available for viewing through the MOE Nelson office.[4]

To assess LU K-18 in relation to the surrounding landscape units, a database-driven map was produced at 1:50,000 (Map 2) showing themed age classes, topography, and KBHLPO caribou zonation linework. This was created by Timberland Consultants GIS department using updated overlay files from Herbison (2007).

[1] Geographic Information Systems
[2] Vegetation Resource Inventory
[3] Terrain Resource Information Mapping
[4] This map needs work to be viewer friendly

Database queries were utilized to obtain quantitative perspectives on the supply of age class 5, 6, and 7 and old growth on various slope classes in the landscape and in smaller planning units. At the outset of the project, two existing Ministry of Forests and Range sources provided guidance on the status of LU K-18 according to the KBHLPO: A spreadsheet generated by Niblett (2006), as mentioned above, portrays the budget for all KL District landscape units and indicates a deficit of age class 8/9 in LU K-18. Another, informal analysis (D. Anderson, Ministry of Forests and Range, pers. comm.) looked at the area of age class 5, 6,and 7 on < 80 % slope mature forest in K-18 in relation to the age class 8 and 9 deficit. This indicated some flexibility to work with for recruitment, at least in the ICH. His analysis suggests there is an approximate surplus of 1600 ha of age class 5, 6 and 7 in the ICHmw2 and ICHwk1 beyond the deficit, and about 100 ha of surplus in the ESSFwc4, i.e., hectares beyond the deficit.

The project later ran a more detailed database query looking at the distribution of age class 5, 6, and 7 by slope class within planning subunits within LU K-18 and by KBHLPO priority zone. Analyses by subunit were intended to provide more spatially practical information for licensees than the LU as a whole, and were considered to be more meaningful units for caribou, particularly in winter when snow conditions when long distances cannot be traveled easily. The queries provided refined values by calculating area on slopes less than 65%. The decision to run at a 65% slope cut-off was made after field findings suggested this as the approximate slope value separating (amongst other values) high from mediocre quality for caribou. Query spreadsheets and bar charts were created by Timberland Consultants under direction of the author.

Field reconnaissance and sampling

Field reconnaissance routes and plot locations were designed to sample representative examples of as many different age class 5, 6, and 7[5] stand types as possible given access constraints, late-season contract initiation, and budget imitations; plots were all within a 2-hr walk from a 4WD road. Pre-field stand typing was undertaken using TRIM and current 2008 VRI mapping, 1997 air photos, 2005 ortho photos, and 1:20,000 composite maps created in 2007 (Herbison 2007). Earlier caribou habitat assessments, known caribou habitat use, and model-generated mapping were also reviewed and considered (Herbison 1997, Hamilton and Herbison 1997, Hamilton and Wilson 2003). The habitat polygons initially identified for field sampling were more detailed than forest cover / VRI polygons, but after the practical benefits of using VRI polygons became apparent in the context of creating time-series maps, VRI polygon numbers were used (see later in this section for details).

Field-recording methods and field-data collection met the standards required by the Forest Investment Account (FIA), i.e., the District Level Agreement (Hamilton et al. 2004). Reconnaissance-level information was obtained by actively observing all relevant habitat attributes in stands traversed or driven-through en route to and from plot locations, and recording notes coded to numbered locations on maps. These observations were used to tie together stand-level observations, to do a general accuracy check on the

[5] Near the end of the project it became apparent there was a need to check suitability in some age class 8 and 9 stands so additional plots were located there. As well, a few plots were located in age classes 1 to 4 and high-graded types to provide information on lichen establishment.

VRI mapped information, to note large mammal travel focal zones and other habitat features where evident on the ground, to type stands in a quick manner once the basic variations had all been sampled with plots, and to assess the relative biological value (function) of stands in the context of their immediate surroundings.

Wildlife Habitat Assessment (WHA) field forms (Resources Inventory Branch 1999) were used to record plot data relevant to caribou habitat suitability ranking. Ranking criteria were consistent with criteria used elsewhere in the Central Selkirks by the author in plots surveyed for model development in Hamilton and Wilson (2003). Given that the numbered 1 to 6 ranking are somewhat qualitative, however, and that there are several iterations of ranking criteria in writing, the criteria used for early and late winter habitat ranking in this project are spelled out in Appendix B. Stands were ranked in the field for all four seasons, though the time series projections utilize only winter habitat rankings. The RISC standard (Armeleder et al. 1992) was used for ranking forage lichen abundance reachable by caribou from a snowpack by caribou, and additional information was obtained on lichen available through blowdown and branchfall as explained in Appendix B.

Additional plot data collected at the plot level included slope, aspect, elevation, tree age cores (in a subset of each type), a count of all trees by layer, presence of non-lichen foods, photographs, and notes on observed ecological processes that might affect future conditions. Based on stand structure, tree species, observed current processes and expected future processes, a qualitative prediction of expected conditions was then recorded for future time intervals approximating 30, 60 or 120 years in the future.

The assumptions (hypotheses) used to predict future stand conditions and to generate the times series maps were informed by research on stand dynamics by Oliver and Larson (1990), Pickett (1985) and Warring (1998), by informal observations of forest succession by the author in West Kootenay ecosystems over the past 30 years, and by standard ecological theory regarding forest succession specific to BEC and forest type in B.C. (Krajina 1972, Kimmins 1987). In stands dominated by early or mid-seral species (e.g., lodgepole pine), a change in species composition was predicted along with a change in structure. In stands assessed to be in a climax condition, dominated by self-perpetuating species, species composition was projected to stay the same but changes in structure were expected with age, at least on mesic to moist sites (e.g., increased gappiness, larger diameters, more snags, and increased large coarse woody debris). In the case of present-day openings (age class 2 to 4 stands) it was assumed that they would progress towards the tree species and structure represented by old and mature remnants in their vicinity on similar slopes and soils. This is a weakness could be refined in future iterations; plantations will not necessarily follow the same successional path as the original stand. A gradual decrease in fragmentation was assumed in this iteration, i.e., no timber harvesting, fire, or other large disturbance events. This would also need to be remedied in future time iterations.

Four examples are provided in a sketch in Appendix B that show how future conditions were projected and ranked for four major stand types.

It is recognized that the major climatic changes predicted for the next century will likely affect future conditions in ways that cannot be accurately predicted. The projected 120-yr condition is especially questionable in this regard. This exercise is very much experimental; its purpose has been to pilot the potential feasibility and usefulness of the technique as a planning tool.

Post-fieldwork mapping and analysis

Following fieldwork, all stands in LU K-18 that were not sampled or viewed directly were typed based on extrapolation from field samples using air photo typing in the manner normally used by TEM and forest inventory mapping. Variation in reliability is recognized. Age class 5, 6, and 7 stands with similar structural or other attributes of significance to caribou were classified into a total of 17 different types in the first round of summarizing as shown in Table 1, Appendix B. However, recognizing a need to "lump" to be useable, a greatly simplified map later portrayed stands by their suitability ranking only, coded by colour, as shown on Maps 3A and 3B.

After some trial and error in portraying findings digitally to project through time, a spreadsheet was provided to Timberland Consultants based on the above assumptions and classification. The sheet assigned each age class 5, 6, and 7 polygon a colour class (ranking) and subclass, based on present conditions, and each subclass was assigned its own set of instructions for future colour class (ranking) at each time interval (30, 60 and 120 yrs) based on projected processes and predicted stand conditions. Only winter habitat conditions are ranked in this exercise, with ranking colour reflecting values for either early winter or late winter, or both (i.e., if *either* one ranks high or medium, polygon will show as high or medium). It was determined to be complicated and unproductive to run separate files for the two winter seasons, or to code each separately on the same map over time. Table 1, Appendix B indicates whether ranking is for early or late winter values. Stands in the ICHmw2 below 1000 m can be assumed to be early winter only. Stands above 2000 are normally late winter only. Stands between these two elevations can be either, or both, if the calendar is used to define the season, or can be used in the transition period between the two seasons. The classic early-winter conditions are characterized by deep snow in which movement is hindered, preceded by shallower snow during which time evergreen plants and succulents in seeps are often used, sometimes by cratering. The classic late-winter conditions are consolidated, deep snow on which caribou travel freely and stand to reach lichens. In many winters snow conditions change in unpredictable patterns and the classic early- and late-winter separation is less distinct; in such winters caribou are believed (by this author) to go up and down between elevations frequently and likely require a diversity of forest conditions.

Considerable experimentation was required in merging the field-tuned information for age class 5, 6, and 7 polygons in a compatible manner with the backdrop map which continued to use standard current VRI data, with simple additive aging, for the other age classes. In the end, shape files were created from the project polygons and these were transplanted into the VRI-themed layer, at each time period. The present time series

projections are an altered version of what would result from a simple projection of time series using standard VRI data.

Results

Age class and ecosystem conditions in the regional landscape and the KBHLPO Central Selkirk caribou management area.

The regional age-class map, (L. DeGroot, Ministry of Environment, unpubl.), indicates there is relatively little area occupied by age classes 5, 6, and 7 within the KBHLPO Central Selkirk caribou line work compared with older or younger age classes. A significant portion of the total area is located in Landscape Unit K-18. Mature stands are somewhat more prevalent in the landscape outside the KBHLPO lines, and appear to be concentrated primarily on or near main lake and river valley faces (e.g., lower and upper Arrow, Kootenay Lake, and Slocan Lake). It is evident that much of the mature age class is in a fragmented condition, and that the largest unfragmented matrixes of this age class lie well outside the KBLHLP caribou linework and outside present core ranges.

It appears likely that changes in line work under SARCO based on the March 30 draft may include new areas of age class 5, 6, and 7 along the upper Arrow Lake near Nakusp, and may exclude some mature age classes in K-18 that are now in KBHLPO as discussed further below.

Age classes, slopes, biogeoclimatic variants and KBHLPO line work within LU K-18 and adjacent landscape units at 1:50, 000: Map 2.

Map 2 and the subunit queries illustrate many of the same points discussed above but also provide detail on BEC variants and topographic conditions, combined with age class, specific to Landscape Unit K-18. It can be seen that most of the age class 5, 6, and 7 stands in LU K-18 on gentle slopes[6] are located along the Trout Lake/Lardeau River face, and that in the ICH these are, as noted, in a more or less fragmented condition. ESSF stands of that age class tend to be less fragmented. The rest of the mature age class in K-18 is located in Healy Creek: along the lower canyon (Subunit D), much of which is of marginal value to caribou due to slope steepness, and above Skinner creek (Subunit A) on the eastern slope. The latter stand north of Skinner is age class 7, spans ICH and ESSF variants, and it is limited to a moderate level of suitability and capability by slope steepness and rockiness. Gentle slopes in the ICH (of any age class) are rarities in all side creek drainages within KBHLPO caribou line work, located primarily along narrow valley-bottom and toe-slope zones and on occasional mid-slope benches. A large proportion of these have been harvested.

As the map indicates, virtually all of the age class 5, 6, and 7 in the ESSF in K-18 is captured within KBHLPO Zone 1 (loosely protected). ICH mature stands lie in both Zone 1 and Zone 2 (special management). Several hundred hectares of age class 5 and 6 in the ICHmw2 are located within the Goat Range Park between Gerrard Creek and Healy Creek. New SARCO line work may exclude approximately 800 ha of age class 5

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[1] Gentle slopes are generally better quality winter habitats for caribou than steep slopes.

and 6 in LU K-18 that now lies within KBHLPO Zone 2 south of Healy Creek: the Hope Creek face (Subunit C1).

Subunit queries and bar chart summaries: Appendix B.
The queries and bar charts illustrate the situation that is visually evident on Map 2: that Healy Creek has only 113 ha of age class 7 on slopes less than 65% in the ICH (a total of ~ 200 ha on slopes < 80%), whereas Silvercup Ridge and Hope Creek support approximately 1300 and 800 ha, respectively, on slopes < 65%. The totals indicated by these queries as they relate to KBHLPO requirements are similar to those generated by Anderson; technically speaking there appears to be a surplus of approximately 1000 to 1600 ha in the ICH beyond that required to meet the age class 8/9 deficit.

Field-refined suitability mapping of age class 5, 6, and 7 stands in LU K-18: present conditions as shown on 1:20,000 Maps 3A and 3B, in Table 1, and 1:50,000 Map 7A.
Map 3A and 3B show present conditions simplified by standardized winter habitat rankings: the dark blue polygons rank moderately high in suitability, verging on high (Class 2+). Light blue polygons rank moderate: 3 and 3+. Mauve indicates a high ranking for age classes 8 and 9 stands, with the caveat that this is largely an assumption, as most age class 8/9 polygons were not field checked. Table 1 provides additional details on the 17+ stand variations, with number rankings for suitability tying the more complex typing to the simplified colour-themed map. Table 1 specifies whether the ranking applies to early winter, late winter, or both.

Key field findings of interest that were factored into building the time-series map projection.

- Most of the age class 5, 6 and 7 stands sampled in the ICH and transition zone ranked moderately high to high for caribou (Class 3+ to Class 1 in terms of *present* suitability. Most supported very abundant lichens: Class 4 to 5 (abundant and very abundant) loadings were common.

- Equally surprising, lichen *availability* was moderately high to high, occurring not only through whole tree blowdown and branchfall as part of the "understory reinitiation stage" as coined by Oliver and Larson (1990), but also through the fact that lichens were found growing in abundance within 2 m of the ground on trunks and low branches. This was most noticeable on Silvercup Ridge. This situation is of particular interest given the concept that caribou may (increasingly) need to forage at lower elevations, even in late winter, in years when there are lower snowpacks at high elevations (Kinley et al. 2006; detailed explanation based on lichen biology found in Goward 1998).

- Stands strongly dominated by lodgepole pine (Pl) appear to be serving a very important role in supplying food for caribou at present due to a number of factors: (1) most Pl stands are located in the ESSF-ICH transition zone, an identified high-use zone for caribou (Hamilton and Herbison 1997); (2) in some locations Pl types predominate (i.e., are "all that is left") due to an earlier harvest focus on

other species upslope and downslope; (3) many Pl stands support very abundant, reachable *Bryoria*,, believed by some researchers to be preferred by caribou over *Alectoria* (Rominger 1995); and (4) in some Pl types lichens are additionally available through the gradual dropping out of pine from the overstory.

- Pertinent to the above, a location dominated by age class 6 Pl BlSx mixtures, the upper American-Horsefly Creek area at the south end of Silvercup ridge, was well used by radio-collared caribou (Hamilton et al 2002) and is typically a ”hotspot” for caribou census locations (D. Hamilton, Nanuq Consulting Ltd., pers. comm.).

- An important observation regarding Pl types, however, is that they appear to be at their peak for caribou at age class 6 (possibly age class 5 in some cases), and to have declined in suitability by age class 7. The age class 7 Pl types sampled were falling over at a rate that created potential mobility issues (except on very deep snowpacks), standing trees had lost their lower branches, and they no longer supported abundant lichen on their trunks. This was the case whether or not there were beetle infestations in evidence. The duration of the temporal gap created by the succession of Pl stands will presumably depend on the extent to which Pl is the dominant species as well as the characteristics of the understory. It will be relatively short or lacking where there are other tree species in the mix. In pure Pl stands, the gap will be shorter (30-60 yrs) where there is a well-advanced understory of Bl and Sx inoculated with lichens but longer (> 100 yr) where there is no understory, or where the stand is harvested and the understory is removed. This illustrates the fact that age in itself (and slope) cannot be used to predict suitability or supply over time.

- Lichens were found establishing on surprisingly young trees in certain situations: *Alectoria sarmentosa*, abundance Class 1 (low), on 20-25–year–old Douglas-fir where older single trees or old growth fragments were within 200 m (upslope); *Bryoria,* abundance class 2 (moderately low), on 17-year-old western larch in plantations lying well over 200 m from an obvious source of *Bryoria* but within 200 m of older stands, and *Alectoria* (mixed with *Bryoria*), abundance class 3 or 4 on western hemlock trees 60 years old where located beneath older, taller trees in ”high-graded” stand types logged 30-40 yrs ago. These findings support current theories regarding lichen inoculation (Esseen et al. 1996, Goward 1998). If one assumes future lichen growth continuing at the same rate, these stands could in theory support Class 5 (very abundant) lichens in 100 years, more conservatively, in 120 years. This is consistent with project findings of Class 5 lichens within present age class 5 and 6 stands.

- Most stand fragments sampled and observed (even those < 200 m wide) supported abundant *Alectoria sarmentosa* and, in some cases, abundance was clearly greater near the outside edge of the fragments. This would appear to contradict findings by Stevenson and Coxson (1999) that indicate a loss of this species in partial cuts; however, it is consistent with findings by Esseen and Renhorn (1998) that *Alectoria* had recovered within 20-30 m of edges in approximately 20 years due,

they supposed, to increased light. All of the openings next to the fragments observed in the present project were at least 20 years old. Microclimate could also be a factor: there is an obvious and prevalent"fog belt" along Trout Lake and the Lardeau River (pers. obs.) that appears to hold high humidity levels. This may mitigate edge effects

- *Alectoria* and *Bryoria* mixtures were still alive and abundant on dead trees in the Skinner-Madden-Healy 2003 burn. Similar observations have been made by the author in other burns over the years, such as the Hatteras and Nemo burns in the upper Duncan. There are also, of note, many records of caribou using old burns in winter during periods when crown closure is not required. These include telemetry locations in Hatteras, Nemo, and upper Duncan, and census locations in 2004 and 2008 in the Skinner-Madden-Healy burn (Hamilton and Herbison 1997, and D. Hamilton, Nanuq Consulting Ltd., pers. comm.)

- In all stands sampled, forest health "problems" were clearly noted to be an integral part of the understory re-initiation stage (Oliver and Larson 1990), and they appear closely linked with lichen availability for caribou. As the dominant species in a stand fall over, slowly decline and break, they provide a good supply of lichens.

- The findings in this project along with incidental observations by the author elsewhere in the Central Selkirks suggest that not all age class 8/9 stands on reasonable slopes are suitable caribou habitat, and that not all presently suitable age class 8/9 stands remain so indefinitely. Spruce-leading stands on good sites, for example, appear to have a lifespan of less than 300 years; after that time large-scale blowdown is common. As noted in above sections, lodgepole pine stands of age class 8 (if they were to exist) would likely be poor habitat for caribou at that age. Age class 8 and 9 subalpine fir stands have been observed in which the old trees are largely lying on the ground. Numerous tall hemlock and cedar-hemlock stands on good (near valley-bottom) sites have been observed that have very low lichen abundance levels. All stands experience constant change resulting from successional processes, and the nature of those changes is often difficult to predict. These observations suggest that in some situations mature stands may be needed to complement or supplement old growth; to supply lichens, for example, or to buffer fragmentation.

Maps 4A/4B, 5A/5B, and 6A/6B provide an experimental projection into the future of caribou habitat suitability at 30 yr, 60 yr, and 120 yr based on the assumptions described. As stated, in light of the all the variables noted above and the numerous additional unpredictable influences that could occur, all predictions need to be interpreted cautiously. The long-term (120-year) prediction needs to be considered especially hypothetical, for all age classes. It does appear there would be a difference between future projections using simple database age plus time and projections using field-refined type-based differences expected over time. The field-based spatial and temporal situation appears to be more complex, and more realistic.

Conclusions and Recommendations

It is clear that a number of factors need to be considered along with stand age if attempting to plan or predict the temporal and spatial location of caribou habitat supply over long time periods and over large, (or small) land areas. Pertinent to stand-level winter habitat needs, the timing of abundance and availability of lichens appears to vary widely between stands of similar age with differing tree species dominance, and even among stands having the same species dominance and age but differing understory characteristics. It is also affected by the proximity to older lichen-bearing stands, topographic and other site features, forest health, and other factors. Even old burns serve as suppliers of lichens when consolidated snow conditions allow the use of stands with little crown closure. Pertinent to all-season, landscape-level population habitat needs for caribou, it appears the dynamic temporal-spatial qualities associated with forest stands need to be factored in for effective long-term caribou recovery over the broad landscape. ***It is recommended that further work be undertaken to refine correlations between peak lichen productivity/ availability and dominant tree species, site, understory characteristics, and forest health and other considerations, and that these then be factored into modeling caribou habitat supply and other forms of caribou habitat analysis at a variety of scales.***

Given that many age class 6 and 7 stands and some age class 5 stands are now suitable for caribou, and that they appear to be important complements to age class 8 and 9 stands in supplying lichen and buffering fragmentation in many locations, ***it is recommended that any proposed timber harvesting in mature age classes in caribou habitat be preceded by a thorough field assessment that evaluates stand-level attributes as well as the relative function of the stand in its surroundings.*** This assessment should carry the weight of the decision rather than database hectare numbers and aspatial rule sets.

The above recommendation applies equally to lodgepole pine stands, including those attacked by bark beetle, and to all stands with forest disease or insect attack conditions. ***It is important to recognize the possibly vital role of tree disease and insect outbreaks in lichen supply and availability for caribou and to give fair weight to this function in decisions regarding forest health.***

The main river and lake valley face units in K-18 and throughout the broader Central Selkirk caribou range may have a significant role to play in the recovery of early-winter caribou habitat. There are consistent historic accounts of caribou moving predictably from side drainages to main valley faces in early winter (Herbison 1973), the present project suggests lichen abundance may be higher on face units, and they are clearly the locations that support the gentlest slopes in the ICHmw2 and ICHwk1 BEC units. If the climate warms over the coming decades, as is predicted, the availability of lichens growing lower on trunks and branches in the upper ICH and transition zones, adjacent to traditional late-winter habitats (e.g., as found on Silvercup Ridge) could potentially be more vital for caribou than in the past. ***It is recommended that the potentially high importance of main valley faces be accounted for in planning for caribou at a range of***

scales, and that planners and managers broaden their thinking to consider the role of areas now far outside core ranges in long-term caribou recovery.
It is concluded that time-series mapping such as piloted in this project has potential as a tool for long-term planning of caribou habitat supply given a number of further refinements that are beyond the present scope. The present scale, and even more detailed scales, could be useful for examining the pros and cons of harvesting or leaving any given stand. A much larger landscape area would be required for meaningful analysis relevant for long-term population recovery. One of the next steps would be to add in potential major disturbances such as fires or timber harvesting.

Additional recommended next steps (as appropriate given higher level planning direction) include:

- Refine quantitative measures of habitat supply in K-18 and immediately surrounding landscape units based on the mapping and concepts approached experimentally in the present project. This should include addressing the potential temporal (and spatial) gap that may be forthcoming by the presence of short-lived, but presently contributing, lodgepole pine stands. It should also include field examination of age class 8 and 9 stands that have not already been checked on the ground.

- Revise field methodology, recording systems, and standards for caribou habitat assessments including an expanded field form. New methodology should incorporate more details on standard systems for evaluations at the landscape and sub-landscape scale to precede the stand level[7].

- Look at in-depth prescriptions for stand-tending options in age class 1 to 4 and possibly class 5 stands that might hasten the recovery of habitat for caribou, incorporating findings about lichen/stand/site relationships from the present project and other research. As a related exercise, examine the potential for, and develop prescriptions for, harvesting in specific low value habitat stands. If developed far ahead, these prospects would perhaps be more feasible for licensees when economics were conducive.

- Begin developing systems that facilitate temporal and spatial flexibility for habitat management over very broad landscapes over long time periods but that also maintain optimal habitat integrity for caribou (minimal fragmentation) . It is likely that one important component of such a system would be strong regulatory support for recommendations arising from field assessments. Until an adequate system has been developed, spatially "fixed" protected habitat areas are the most secure form of management for caribou.

[7] Landscape-level assessments are vital precursors to stand level assessments of any age class for caribou, to consider influences such as habitat fragmentation, topographic conditions, proximity to other seasonal caribou habitats, proximity to other species habitats (e.g., deer and elk winter range), current level of human disturbance, predicted future level of human disturbance and the relative function (importance) of the stand in question in relation to adjacent stands.

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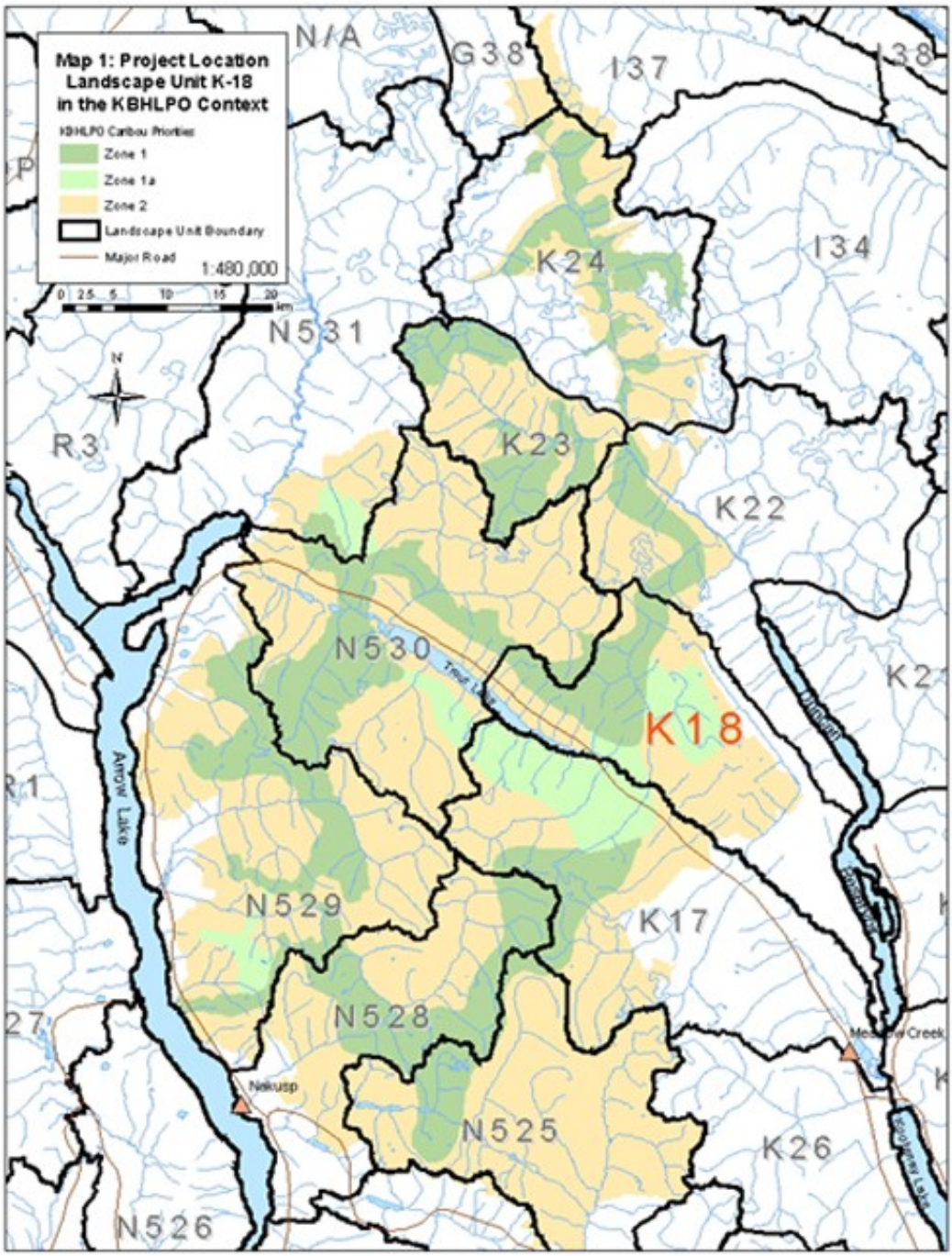
APPENDIX A
Map 1. Project Location



Appendix B

Methods supplement

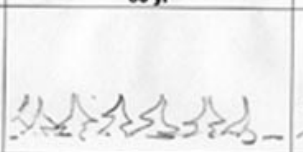
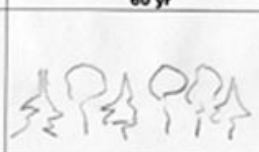
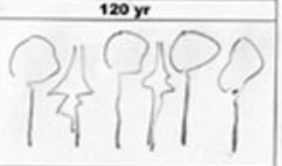
The table below describes stand-level criteria used in this project for distinctions between Class 1 to 4 winter suitability classes, with differences noted for early vs. late winter.

Ranking	Description
1 High suitability	Lichen abundance 4+ or 5 in the stand and plot. High availability of lichens through direct reaching from the normal snowpack height expected for the site, assumed to be 1 m *(classically considered most important in late winter, but where present at low elevations is an interesting and high-ranking feature)*. High availability of lichens through blowdown and branch litterfall (*considered more important in early winter, but may be increasingly important in late winter with decreased snowpacks).* Large patch (matrix) size. Good to moderate crown closure (*important in early winter only*). Easy mobility. Open visibility. Food for shallow-snow period, e.g. Falsebox *(important only in early winter).* Slope < 65%. Proximity to other winter seasonal habitats with documented use by caribou.
2 Moderately high suitability	Slightly lower value rankings on one or more of criteria in list above.
3 Moderate suitability	Lower lichen abundance and availability than above, or similar lichen abundance but steeper slopes, more broken topography, smaller patch sizes, and/or denser stands, and/or further from other winter habitats, lichen abundance class 3 or less, lower availability, smaller patches, steeper slopes than 2s, an /or closer to roads.
4 Low suitability	Virtually no lichen or other winter food available and/or no crown closure (young stands).

Additions to Armeleder et al. (1992) used in this project

Lichen abundance was quantified below 3.5 m rather than 4.5 due to expected lower snowpacks here than in Prince George.
Height from ground of lowest abundant lichen was noted on sample trees and plot.
Characteristics of structural attributes supporting lichens were noted (e.g., branches, trunks, or understory).
Lichen abundance was recorded in crown of sample trees, and average in crowns in plot in addition to reachable lichen.
Overall lichen overall *availability* was rated for the plot and stand as a whole. This was a qualitative ranking based on the sum of visible blowdown and branches on the ground (old and fresh) lichen abundance in tree crowns and upper branches, the condition of the crowns and upper branches (whether or not breakage-prone), and the amount of lichen reachable directly from the ground.

Hypothetical changes in caribou early winter suitability ranking with projected structural and tree species shifts over time: four stand type examples

Type	Now	30 yr	60 yr	120 yr
Pl AC 7 with little/nil understory E.g., Aii				
Ranking	3	5	3 or 4	2 or 3
Pl (B,S) AC 5,6, with advanced understory of B(S) E.g., Ai			 → old growth BS	
Ranking	2+	2+	1	1
Fir (Bl) AC 7 on dry steep rocky sites E.G., Cii	 → Douglas fir edaphic climax no major change expected →			
Ranking	3 2 on benches	3 or 2	3 or 2	3 or 2
Fir (Hw,Cw,Lw Pl, Pw) AC 5,6,7 Mesic sites E.g., D	 Dense	Decreasing density over time and shift to climax →	old growth Hemlock / Cedar	
Ranking	3 or 2	1 or 2	1	1+

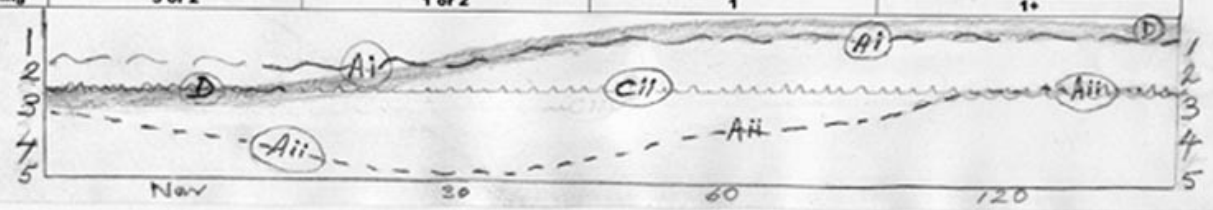


Table 1. Mature stand types in LU K-18 with present and projected future winter habitat suitability ranking for caribou

Ref. No.	Type Description		Example Location	FCpoly# (example)	Plot #s	Winter* Suitability Ranking				Management Implications and general comments
						Present	30 years	60 years	120 years	
AGE CLASS 5, 6, AND 7, MATURE FOREST TYPES										
A: Pl Variations. Age class 5 and 6									??????	
Ai	PlSxBL (Fd in some)	ESSF(Trans)	Amercican Cr.	185	3	1	1 or 2	1	1	Due to presence of Bl, Sx and other spp., not likely to
		trans	Gerrard Cr.	187	2	WL				have future 'slump' in caribou suitability
	Class 4+/5 Lichen Abundance			529	4	WE				No obvious insects or disease but likely fire-prone
	High availability through direct reachability			342	5	Trans				High priority for fire protection
	Variable crown closure									over next 20 years
Aii	Age Class 7		north of	If harvested	11	2(3)	5	4	2	"Past their prime" for caribou
	losing lower branches		Neil Cr.	252						Decreasing lichen abundance/availability
	Pl falling over		Hope Cr	No harvest	6	2(3)	3	2	1	Increasing mobility issues
	Class 4 lichen but not directly reachable					WL				Understory variable
						WE				(This lumping could be further separated
						Trans				on stand-specific understory condition)
Aiii	Pl Ac5	ICH/ESSF	Rady	422		3	4	4	3	Exceptionaly small dbh trees
	smalldbh	trans				WL				This stand type can only be ID'd
	few lower branches					WE				very site-specifically
	Mod licheb abundance'Mod/low avail					Trans				Poor site (<20% live crown even tho' widely spaced
	Decreasing. Low cover									
	Class 3 Lichen and low availability									

Ref. No.	Type Description	Example Location	FCpoly# (example)	Plot #s	Winter* Suitability Ranking				Management Implications and general comments
					Present	30 years	60 years	120 years	
B: Fd Bl Hw Sx Pl Pw Mixed species variations									
	Upper ICHwk1/lower ESSFwc4/cu4								
	Multi aged and single aged (6 and 7) stands								
Bi	F(Pl) H,Pw	ICH/ESSF	south of	<65%		3	2	1	1	Diverse stand - gappy ("dog's breakfast"
	BlSxCw)	trans	Stobart		7					Pl has fallen out ~ 15 yrs ago
	Disturbed	AC6		>65%		3	3	3	3	Abundant lichen/moderate avail
	Class 3 lichen, low availablity									Higher values for other wlf species than some of
	High % herb layer									the better caribou stands (bears,rodents, songbirds,
										grouse)
Bii	F, H,Pw	ICH/ESSF	bl 8	182	1	1	1	1	1	Diverse structure, diverse spp mix
	BlSxCw)	trans	WTP							Predict will perpetuate over time
	Rich site	Very high structural diversity								High suitability for spring and fall
	Gentle slope									as well as early winter weigh
	Lichen class (4) lower than some but good									
	crclosure and other food plants and adjacency									
	This stand includes 300 + year-old Fir,Hw and Cw - misrep'd by "age class 6"									
Biii	F (Cw)	ICH/ESSF	bl 6	253		2+	1	1	1	High value recruitment stand due to fact that
	Good site	trans								Pl has already fallen out (~ 15 yrs ago)
	Moderate			If harvested		2+	5	4	3 or 2	so will not have"slump" as much of surroundings
	slopes									Fir predicted to thin, not all die, and to
	Hw understory									make lichens available in the process.
	Fir crowns indicate "understory reinitiation" stage is beginning									Poly 253 is included in CP 279
	Reachable Alectoria growing densely on Fir boles to 2.5 metres									Recommend leave unharvested, but alternatively
										remove ~ 1/2 of less healthy Fir
										and do not damage Hw understory

Ref. No.	Type Description	Example Location	FCpoly# (example)	Plot #s	Winter* Suitability Ranking				Management Implications and general comments
					Present	30 years	60 years	120 years	
C : Low elevation Douglas Fir (Bi, Pw)									
		ICHmw2							
			Hope						
Ci	F (Pl)		Creek	9	2(3)	2	2	1?	Pl has been falling out for ~ 10 years,resulting in
	(CwLw,Sx)	mesic							~ 50 % cwd cover in some patces
		benches							
	more cwd, less steep than below								
	Class 4 Lichen abundance but availability largely through blowdown. Growing to 3 m from ground but low snowdepths here								
	Alectoria s. and Bryoria capillaris(?)								Gradual progression to Cw/Hw (Fd) expected
Cii	F(Bi,Pw)	ICH	lower	39	2(3)	2(3)	2(3)	2(3)	Likely to maintain an edaphic climax condition
		lower	Hope						on these dry rocky sites
		dry/rocky	Creek						
		steeper	face						*NB: Ranking on Hope Cr. Face is affected by context*
	Extremely abundanct (Class 5:) lichen on Fir and Birch (Alectoria and Bryoria c.)								*(minimal WI habitat above/no recent records)*
									As surrounding fragmentation
Ciii	Similar type to above	ICHmw2			2	2	1	1	reduces
	but on lower Silvercup ridge and lower Healy Cr.				WE				the value of this stand wil increase
	Lower slope	ridges							where not too steep
	FBi (Pw)	drier sites							Birch supports abundant Alectoria
	Class 5 + Alectoria (less Bryoria)								(as do the conifer spp)
		Lower Stobart							Suitability predicted to improve
		south to Neil Creek							as fragmentation decreases
									with aging of surroundng stands
Cv	As above but steeper	below			3 (4)	3 (4)	3(4)	3(4)	65+% slope. Lies below Hwy 31
		Hwy 31							
D: Age Class 5 FCwHwMix		south of and			3	2	1	1	Extensive area, most in GRPark
ICHmw2		around							Large matrix size and high potential
		Gerrard							for 'longevity'
		creek			Ranking reduced on steep slopes as indicated on map but otherwise expected to improve with time				

Ref. No.	Type Description	Example Location	FCpoly# (example)	Plot #s	Winter* Suitability Ranking				Management Implications and general comments
					Present	30 years	60 years	120 years	
E: Age Class 6/7 Mixtures (ICHmw2)									
Ei	Cw/Hw/Pw	Healy Cr.			2	1	1	1	
	benches	canyon							
	accessible for caribou from upper Skinner Creek/Hope Cr basin								
Eii	Fd/Cw/Hw/Pw	Rady Cr		29					
	poor sites	Healy Cr	slopes<65%		4	3	2	2	
	steep	canyon			These stands tend to be dense, dark, with low to moderate lichen abundance				
		Above Hwy 31 on			Where accessible for harvesting they might be improved for caribou by partial cutting				
		steep slopes American to Neil			Some of them will likely self-thin and improve with time				
			slopes>65%		4	4	4	4	Notable exception to common assumption that toe-slope=highvalue old growth
F:Upper East Healy Creek		ICHwki and ESSF vars			2	2	2	2	
F	BlPwHw	upper east			WE				radio telemtry locations and field
	Generally steep	Healy Cr.			WL				observatios indicate useable
	Class 4/5 Lichen abundance								habitat but not prime
	High lichen availability ; Bl has been gradually fallig out of stand and is replacing								This is an extensive stand of age class 7
G	CwHwPlF	Hope Cr			4	3	2	1	
	mixed spp				WE				
	Dense				Predicted to become good WE habitat over time				
	Lichen class 3				as stand thins and matures				
H: Larch types									Lake Creek face was sampled lightly for info
Hi	Lw (Fd)	Lake Cr			3	3	2	2?	but in end not included on map
	Extremelyabundant Bryoria but not available				WE				

Ref. No.	Type Description		Example Location	FCpoly# (example)	Plot #s	Winter* Suitability Ranking				Management Implications and general comments
						Present	30 years	60 years	120 years	
Hii	LwFHCwPl		Hope Cr			3	2	2	2	Ranking of 1 should maybe be 2 depending on future management of Hope Creek face (whether more or less fragmented)
SELECTED EARLY SERAL STANDS						5	4	2	1	
	Larch 17 yrs old Class 3 Bryoria already	ICHXX	lower CP 145			WE				
	Plantation Fir 30 yrs old Lichen Class 1	ICHXX	lower American Cr.			4 WE	3	2	1	False Box exceptionally prolific will contribute to late fall/early winter food supply in an estimated 60 yrs once cover est'd
	Highgraded Bi, Pw, F Hw ~5m growing beneath	ICH/ESSF Trans	old CP 145 north of Neil Creek lower Hope			3 WE	3	2	1	
	Heavily highgraded Mistyped as "Age classs 9"		Rady			3 WE	3	2	1	
	2003 Wildlfire					3 LW	4	4	2	