North Coast LRMP

Environmental Risk Assessment: Base Line Scenario

Mountain Goats

Prepared by

Brad T. Pollard, R.P.Bio.

Acer Resource Consulting Ltd., Terrace, B.C..

March 2003.

British Columbia

Table of Contents

1.0 Definitions and Abbreviations 4

2.0 Introduction 5

3.0 Methods 6

3.1 General Approach 6

3.2 Indicators 8

3.3 Assumptions 10

3.4 Analysis and Models 11

4.0 Results 13

4.1 Indicators 13

4.2 Risk Assessment 15

5.0 Discussion and Conclusions 16

5.1 Indicators 16

5.2 Risk Assessment 17

5.3 Uncertainties 18

5.4 Impact Mitigation 18

6.0 References 19

Appendix 1: Relational Tables and Probabilities In Mountain Goat Risk Network..... 23

Appendix 2. Complete Data Set of Indicators for Mountain Goat Risk Assessment .. 25

Executive Summary

The mountain goat is a yellow-listed ungulate that occurs throughout the mountainous regions of British Columbia including the Coast Mountains of the North Coast Forest District. In other jurisdictions evidence is mounting that uncontrolled development has had, and continues to have, negative impacts on individuals and populations. The primary factor at risk with mountain goats is their winter range because development in their largely alpine summer range is highly limited.

This Environmental Risk Assessment (ERA) uses three indicators, - loss of snow interception, relative increase in road-associated disturbance, and population fragility,- to establish the risk to mountain goat populations in 33 Landscape Units (LUs). Data were derived from provincial databases and the North Coast Landscape Model (run in program SELES). Indicators developed were run through a Bayesian Belief Network to provide risk values with levels of uncertainties.

The results indicate that the majority of LUs have a very low or low risk. Two Landscape Units were identified with a moderate risk rating. On a District scale there is less than 5% overlap with the timber harvesting landbase although individual Landscape Units, such as the Kitsault, show up to 25% overlap between goat winter range and the timber harvesting landbase. Calculations suggest that most harvesting will remain within the natural range of variability of forest cover in goat winter range within each ecosection. Increased road disturbance will also increase the risk in some Landscape Units but should be interpreted with caution due to vagaries in the calculation of the road related disturbance indicator. Possible mitigation options to perceived impacts are provided.

1.0 Definitions and Abbreviations

Base Line (Base Case) – The land use scenario defined by perpetuating current management practices into the future.

Ecosection – An area with minor physiographic and macroclimatic or oceanographic variation, defined at the sub-regional scale.

Environmental Risk Assessment (ERA) – The technical process of providing information on the potential implications (risks) of projected land uses on environmental values. This is based on the premise that divergence from natural patterns increases risk.

Landscape Unit (LU) – A sub-regional contiguous area of land, defined at least in large part by watershed boundaries, within which environmental resource values can be summarized.

Range of Natural Variability (RONV) – The range within which an environmental value or resource will fluctuate when affected by disturbances and changes induced by factors other than human-induced factors.

North Coast Landscape Model - The computer model that summarizes changes in landscape condition, spatially and temporally, and is driven by data sets compiled by the North Coast Government Technical Team and modelling assumptions set by domain experts and LRMP Table recommendations.

SELES (Spatially Explicit Landscape Event Simulator) – The computer modelling language, simulation engine and spatial database in which the North Coast Landscape Model is programmed and run.

2.0 Introduction

Mountain goats (*Oreamnos americanus*) belong to a small group of antelopes whose closest relatives live in Europe and Asia. They are endemic to the mountains of western North America and secure populations are present in Washington and Montana, extending north through British Columbia into the Northwest Territories, Yukon and Alaska. Smaller numbers are also found in Alberta, and some states including Oregon, Nevada, Utah, Wyoming, Colorado and South Dakota, although these are generally introduced (Johnson 1977, NatureServe Explorer 2002). British Columbia has the greatest area of natural goat range and supports over half of the world's population (Krausman 1997). They occur on most of the mountain ranges within British Columbia, but are absent from Vancouver Island, the Queen Charlotte Islands, and from most of the Interior Plateau and Peace River Lowlands (Shackleton 1999). Mountain goats are found in all biogeoclimatic zones and ecosections in the NC LRMP area and occur from sea level up to 2000 m.

The NatureServe organization assigns a global ranking of G5 for mountain goats, meaning that they are not considered at risk or vulnerable to species extirpation

(NatureServe Explorer, 2002)[1]. They have also assigned a national ranking of N5 for the Canadian population. A yellow-listed species[2], goats are considered to be "apparently secure" within British Columbia. Other secure sub-national rankings have been assigned for Montana, Alaska, Yukon and Northwest Territories. The exceptions to these secure rankings occur in Alberta and Idaho, where the species is ranked S3 and considered "vulnerable."

A diurnal species, the mountain goat uses a variety of habitats on the coast throughout the year depending on the environmental conditions. During winter months, when snow conditions in upper elevations limit forage availability and their ability to move, they will move downslope to areas with better snow conditions. Wintering areas are usually steep, south-facing slopes with a combination of exposed rock and forest cover. While forest development has rarely occurred in these areas in the past, increased helicopter logging, and the transition to second pass harvesting are putting these winter ranges increasingly at risk (Smith 1986).

The objective of the mountain goat component of the ERA is to determine the significance of development related impacts on populations of mountain goats within the NC LRMP area. Assessment of risk is primarily based on overlap between forested winter range and the timber harvesting landbase, although increasing human access is also considered. The ERA was designed to consider the total impact throughout the NCLRMP area, and the risk within individual Landscape Units (LU). Due to limitations on the approach to meet these scale targets, it was not possible to examine the individual winter range units within LUs.

3.0 Methods

3.1 General Approach

The mountain goat risk assessment uses static and temporal data within a standardized framework to predict the level of risk of maintaining the base line circumstances. Like

---

[1] Conservation ranking status is based on information compiled by field surveys, monitoring activities, consultation, and literature review and is updated each month. "NatureServe" is an international organization of cooperating Conservation Data Centres and Natural Heritage programs all using the same methodology to gather and exchange information on the threatened elements of biodiversity. Based on this information, the NatureServe conservation ranking system assignes global (G), National (N), and subnational (S) rankings on a scale of 1 to 5 with "1" being critically imperiled, and "5" being secure. Source: NatureServe Explorer, 2002.

[2] "The yellow-list includes uncommon, common, declining and increasing species – all species not included on the Red or Blue lists. " Source: Vennesland, R., Harcombe, A., Cannings, S., and L. Darling. 2002. Species ranking in British Columbia…about more that just numbers. British Columbia Ministry of Sustainable Resource Management.

the other ERAs, it is based on a comparison of current and predicted future values against the historic range of natural variation (RONV). These values, or indicators, are measurable data that can be tracked through time and that will reliably reflect the changing risk. With respect to mountain goats, the most relevant indicators include forest cover in identified winter range, the relative increase in human access to mountain goat winter range, and the fragility of impacted populations. Static information from GIS databases provides a range of natural variability and the direct overlap between mountain goat winter range and forest harvesting operability. Data from SELES, a computerised landscape projection model, provides the temporal information relevant for estimating the increase in access-associated disturbance through a 250 year rotation. A rough guide to population fragility by ecosection was developed from the results of a winter range mapping project completed for the NC LRMP (Pollard 2002). Finally, Netica, a Bayesian belief network program, is used to predict the risk to goats within each LU examined based on the output of indicator values.

Much of the mountain goat risk assessment relies on the interpretative winter range distribution mapping (Pollard 2002). All seasons contribute to the size and stability of mountain goat populations but most researchers identify winter habitat as the most limiting (Hjeljord 1973, Hebert and Turnbull 1977, Macgregor 1977, McCrory and Blood 1977, Chadwick 1983, Fox et al. 1989, Del Frate and Spraker 1994, and Smith 1994). When winter snows become deep and heavy, mountain goats will move downslope from summering ranges in the alpine to steep, south facing forested areas. These winter ranges offer reduced snow loading and increased access to forage, and their quality is directly correlated with survival. Because winter habitat is limited and site fidelity is high, small areas of habitat alteration can have large effects on mountain goat population health (Fox et al. 1989). Consequently, mountain goat winter range mapping is an integral part of the risk assessment process and, as such, a more detailed explanation of the mapping process is required.

Winter range mapping was developed using a two tiered approach considering known and suspected patterns in sub-regional and stand level winter habitat selection. South facing, steep slopes with elevational connectivity to summer ranges were identified at the sub-regional scale on 1:50,000 mapping. Areas with a high probability of containing winter range were then examined in detail using aerial photographs and 1:20,000 TRIM maps to identify escape terrain. Historical, anecdotal and concurrent aerial survey information was then used to identify areas with known winter mountain goat use. Those areas with suitable habitat but no supporting information were also identified as unconfirmed winter range units. Winter range polygons often included large areas of escape terrain adjacent to forested habitats to incorporate the requirements of mountain goats for forage and security cover. This information was then digitized into the Ministry of Sustainable Resource Management's (MSRM) mapping database. It should be noted that while this is the best information available on winter range distribution in the NC LRMP area, it is likely that maps will require updating as better information becomes available. A detailed report on methodology, results, and conclusions by ecosection is available from the MSRM. There is no risk analysis available for LUs where no goat winter range was identified.

3.2 Indicators

To assess the risk to winter range in the NC LRMP area three indicators were selected. The most direct, and ultimately most reliable indicator of risk, is the direct impact on winter range through the reduction of forest cover. As indicated, the use of closed canopy forests in winter is well documented in coastal populations (Hjeljord 1973, Schoen et al. 1980, Foster 1982, Fox and Smith 1988, Fox et al. 1989, and Smith 1994). Potential developments within the NC LRMP area that would decrease the snow interception properties of winter range are primarily limited to forest harvesting, although recreational developments and mining could have limited site specific impacts. Consequently, the potential forest cover loss due to harvesting has been assessed in terms of the overlap between the timber harvesting landbase (THLB) and the identified winter range. Data were provided by a GIS analysis of forest cover information. Forested areas within the winter range were calculated using the digitized winter range units and the forest cover data. Data were presented in area based measures for direct comparison within the risk assessment process. See Table 1 for a summary of indicators, rationale, and data sources.

The relative increase in access-associated disturbance adjacent to goat winter range through time was the second indicator used. Second to loss of winter range habitat, increased human access is the next most significant impact of development. As roaded area increases near winter range, hunter and poacher access become easier. Increased kill rates can have devastating impacts on small populations of mountain goats, especially if they are on marginal or suboptimal range (Hatter, 2002). In addition, the disturbance caused by continual traffic on these roads is believed to reduce population productivity (Joslin 1986). Consequently, a relative measure of the road use within 300 m of winter range was tracked by LU through a 250 year window. The 300 m distance reflects a combination of factors. First, if roads approach within 300 m of winter range, there is a good possibility that harvesting will occur within 150 m based on standard cable logging practices, the most likely method of harvesting in road accessible sites in goat habitat. Second, at 300 m, mountain goats will likely be visible on their escape terrain and consequently more likely to be a target for hunters and poachers. Finally, while definitive data are not available, 300 m would likely be the minimum distance necessary to limit road traffic related disturbance on a wintering population of goats.

Helicopter use associated with recreational activities and logging is also believed to have significant impacts on winter goats (Foster and Rahs 1985, Cote 1996). However, no definitive winter helicopter harvesting or recreational use areas could be identified as part of this assessment so they could not be incorporated in a landscape scale assessment. No RONV for access-associated disturbance is possible, consequently the access associated disturbance indicator is a representation of increased rates of human disturbance for comparisons between LU and ecosections. The NC Landscape Model (SELES) includes projected road densities and distributions through a 250 year rotation.

Table 1: Summary of indicators, their rationale, and data sources.

Indicator	Rationale for Indicator	Data Source(s)	Scale/Age of Data
THLB overlap with identified goat winter range	Corresponds to capability of winter range. A direct and reliable measure over several spatially and temporally different scales.	Forest Cover Mapping	Forest cover inventoried at 1:15K. Last re-inventory for North Coast completed in 1995. Portions of inventory are updated annually. Current inventory updated to 1999.
		Winter Range Mapping	Completed in 2002 at 1:20K scale but incorporating 15K aerial photographs. Added to GIS database in 2001. Both confirmed and unconfirmed winter range units considered.
Road-associated disturbance within 300 m of goat winter range	Required measure of human disturbance through time.	NC Landscape Model (SELES Version 8.0)	Based on forest cover inventoried at 1:15K. Last re-inventory for North Coast completed in 1995. Portions of inventory are updated annually. Current inventory updated to 1999.
Population stability by ecosection	Important in establishing potential for impact recovery and risk.	Mountain Goat Winter Range Mapping for the North Coast Forest District (Pollard 2002).	Subjective assessment based on field reviews and mapping in 2001. Best available information.

The final indicator incorporated into the model is ecosection. During the winter range mapping it was noted that mountain goat densities and distribution could generally be associated with the ecosections. For example, most populations within the Hecate Lowland ecosection (HEL) were relatively isolated and had low densities. Both these features are directly attributable to the availability and proximity of habitat. Since the fragility of a population and the risk of impact are directly related to these factors, this information was incorporated into the risk assessment. See Pollard (2002) for a full description of goat densities and distribution by ecosection.

3.3 Assumptions

Several assumptions were made due to the lack of locally relevant specifics. Some refer to the quality of information and its application while others address habitat associations. Regarding information quality, the major concern is the forest cover data. It was apparent to all ERA team members that there were significant deficits in forest cover mapping especially in association to older stands in the CWHvh biogeoclimatic subzone. This limitation did not have a significant impact on this assessment due to the limited populations that occur in the HEL. The second concern revolves around using the THLB as a measure of area to be harvested. There are some problematic issues with assumption given that the THLB is a volume measure and not an area based measure. Consequently, large areas currently identified as outside THE THLB could be logged under current and future economic conditions.

While several references were identified that associated significant population declines with adverse winter weather, none was identified correlating the amount of forest cover loss with rates of decline in mountain goat populations. Consequently, the following assumptions were made regarding the association between snow cover loss and the impacts on mountain goats:

- The degree of decline from the ecosection average forest cover in goat winter range directly correlates with the increase in population risk. This assumption requires that all winter range stands within each LU have an equal value and that harvesting and road building are evenly distributed through the LU.

- Harvested stands will never provide snow interception throughout the 250 year time frame. This assumption was necessary to standardize the variations in rotation times within winter range stands and is appropriate in most economic rotation scenarios.

- The average and standard deviation of current forest cover within an ecosection represents a reasonable range of natural variation for individual LUs. This assumes that previous activities have had a minimal impact on forest cover in winter range to date.

The impact of increased traffic on mountain goat populations is also poorly studied. Several studies have indicated mountain goat sensitivity to a variety of disturbances (Foster 1982, Cote 1996, and Caufield et al. 1999) but none have quantified that impact. Consequently the following assumptions were required:

- Road traffic within 300 m of winter range, and the resulting human access, will result in habitat alienation and declines in range productivity, and increases in hunting and poaching.

- The cumulative total winter range within 300 m of a road within the 250 year time span directly correlates with the increase in population risk.

The sensitivity of different LU populations was assessed based on the degree of isolation from other populations, the suspected population densities, and quality of summer and winter habitat. Again, detailed information on these parameters was not available. However, general comments on these aspects provided in Pollard (2002) were assumed to be adequate to assign relative sensitivities by ecosection.

3.4 Analysis and Models

The original data for this assessment were generated by either the GIS forest cover information or the Landscape Model (SELES). Further manipulation was conducted in Excel spreadsheets. Data from GIS analysis were provided in a large table with area breakdowns of goat winter range by ecosection and LU. Within each row, data were further separated into contributing hectares by land use designation. To simplify the data, LUs were first collated into a single dominant ecosection. The total area of winter range units, total forested percentage of the winter range units, and the overlap with the THLB was sorted out for each LU. These three factors were used to provide the initial forested percentage, RONV, and future forested percentage, respectively, and form the basis of the static data inputs. The average and standard deviation were also calculated for forest cover percent of all winter range units within an ecosection to provide an estimate of RONV. This estimate was used to establish risk benchmarks for forest cover loss within the belief network. Note that because the Meziadin Mountains ecosection (MEM) contains only one LU, it was compiled with the Southern Boundary Ranges (SBR) ecosection to develop a RONV.

The temporal data was provided from the Landscape Model (SELES) in a similar database with road statistics for each LU reported for times 0 years (current), 20 years, 50 years, 100 years, 200 years and 250 years. Area measures for total winter range within 300 m of a road were provided as a cumulative measure through time. To standardize this total within the LU, it was expressed as a percentage of the available winter range for that LU. This measure was used as a representation of total traffic over time and was the determinant for road related disturbance.

Once initial data management was complete, the above indicators were collected into a single spreadsheet and run through Netica (see Figure 1). This Bayesian belief network works through the use of relational tables to establish the probability of an outcome based on the selection of specific parameters. These relational tables, where appropriate information is available, can be based on actual findings from field assessments. When this information is not available, as in the case of mountain goat winter range in the NC LRMP area, expert opinion is used with the uncertainty expressed as a broader range of probabilities. For example, if the relationship between forest harvesting in winter range and declines in population survival were proven to be proportional, the relational table would reflect that by expressing a 100% probability of impact. However, when the relationship is unknown, expert opinion can be used to estimate a level of impact and establish its probability based on the level of confidence in that estimate. Consequently, expert opinion may suggest that there is a 75% probability of proportional impact, 20% of limited impact, and 5% of no impact. The relational tables and their probabilities used in this network have been included as Appendix 5.1.

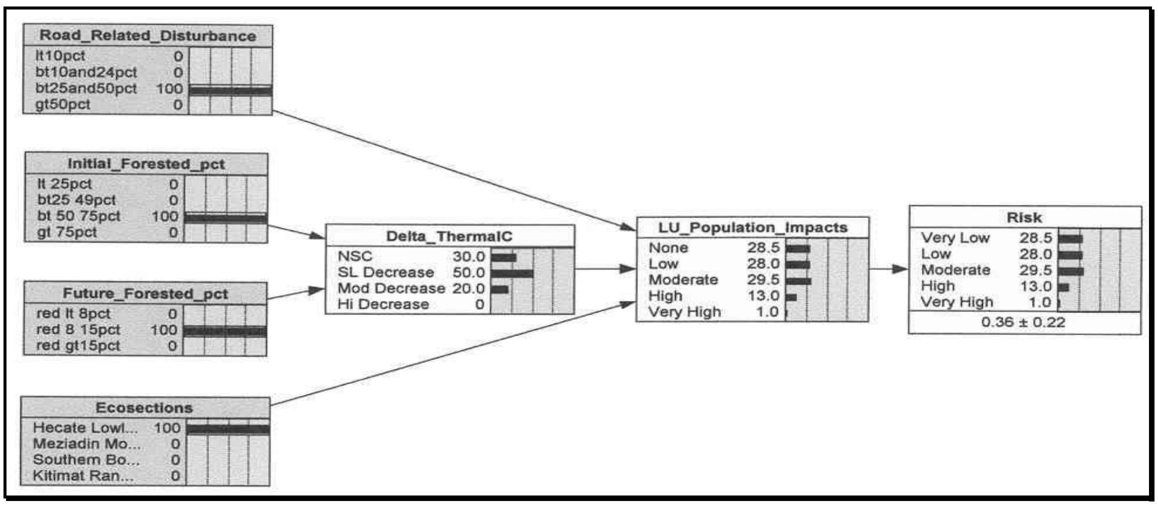

Figure 1: Bayesian belief network influence diagram for development risks to mountain goats based on changes in indicator values.

Within the Netica program there is an option to use discrete or continuous variables. The mountain goat network relied on discrete variables to simplify the development of relational tables. Compartmentalization of variables within each node is based on expert opinion and on the results of the RONV calculation.

The results of the Bayesian belief network are provided as probabilities of occurrence within specified risk classes. Risk values have been standardized for all ERA components into 5 classes including very low (0.0-0.2), low (0.21-0.40), moderate (0.41-0.60), high (0.61-0.80) and very high (0.81-1.0). Because of the uncertainties within the process, an error is output to provide the level of uncertainty associated with the risk values.

4.0 Results

4.1 Indicators

The RONV for the forest cover within winter ranges, and the variations between total forest cover pre- and post-development, were examined on an ecosection basis given the similarities in geography and climate defining them. The results indicate that average forest cover in each ecosection is between 54% and 60%. The standard deviation varies between approximately 10% for Hecate Lowland (HEL) and Kitimat Ranges (KIR) ecosections, and 21% for the Southern Boundary Ranges (SBR) ecosection.

The reduction in forest cover within winter ranges associated with harvesting the THLB varies between LU and ecosection. Landscape Units in the SBR ecosection showed high variation, with the Kitsault LU showing a 25% overlap between the THLB and identified winter range. On comparison with other ecosections, the overlap between winter range and the THLB was highest in the KIR ecosection with an average of approximately 7%. Within the KIR there was significant variation, ranging from no overlap in the Skeena Islands and Khutzeymateen LUs to greater than 15% overlap in the Somerville and Quottoon LUs. The HEL ecosection has the lowest average overlap (an estimated 4%) with individual LUs ranging from 11% (Kaien) to 0% (Pa_aat). See Figures 2-4 for a graphic representation of the overlap within different ecosections and LUs.

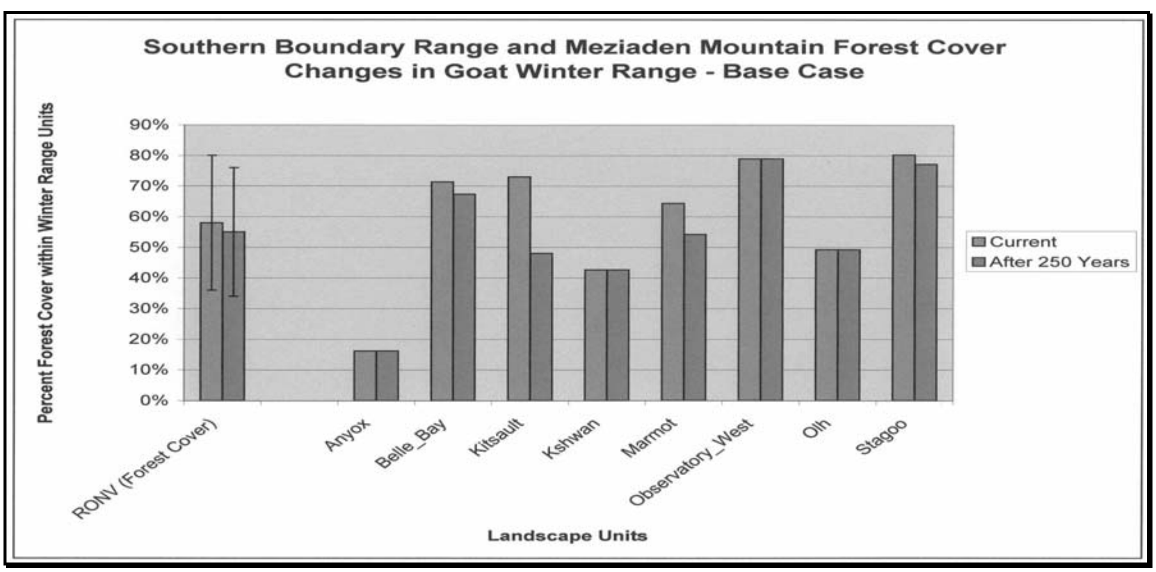

Figure 2: Graphic representation of the RONV for forest cover in winter range polygons in the Southern Boundary Range and Meziadin Mountains ecosection, and the changes in forest cover in winter range due to harvesting within the THLB.

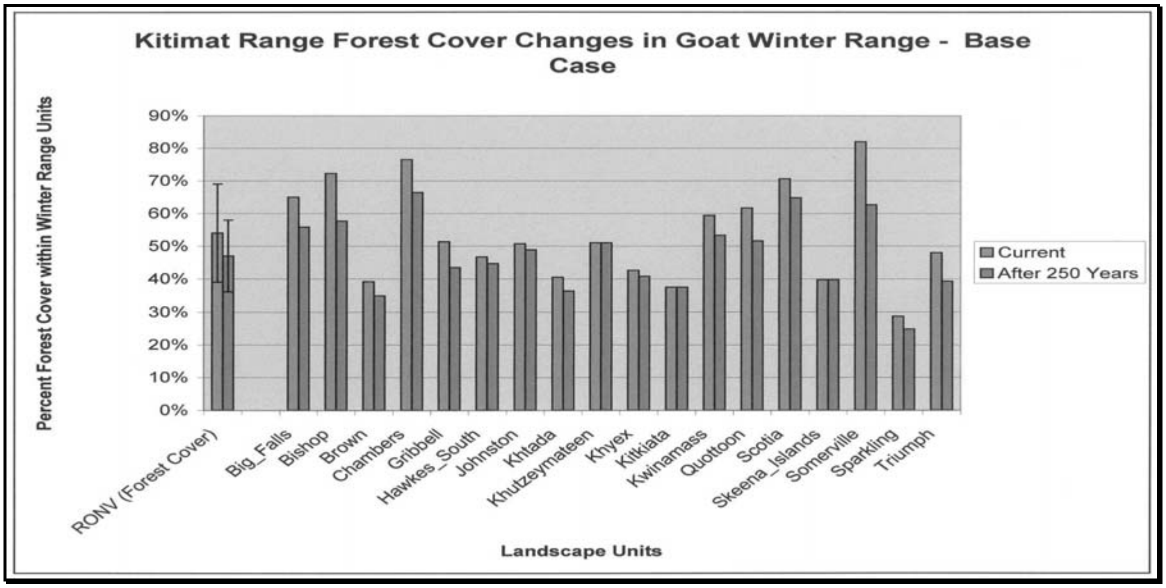

Figure 3: Graphic representation of the RONV for forest cover in winter range polygons in the Kitimat Range ecosection, and the changes in forest cover in winter range due to harvesting within the THLB.

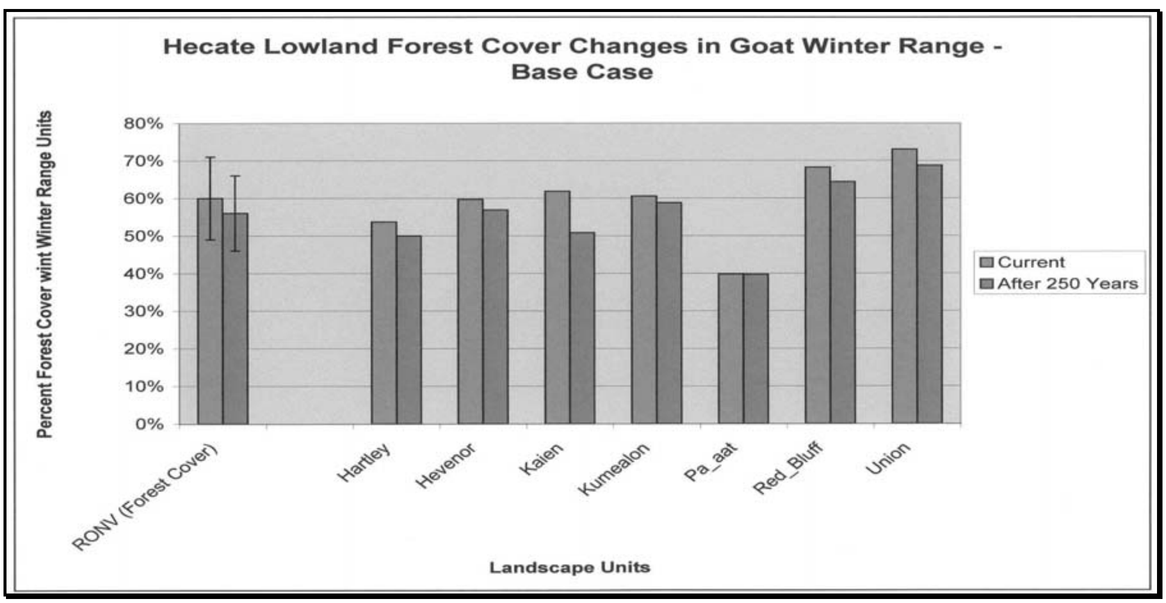

Figure 4: Graphic representation of the RONV for forest cover in winter range polygons in the Hecate Lowlands ecosection, and the changes in forest cover in winter range due to harvesting within the THLB.

Computation of the road related disturbance indicators suggested a wide range of disturbance rates among the LUs investigated. In areas where harvesting was not anticipated, such as the Anyox and Khutzeymateen LUs, disturbance rates were less than 2% due to currently existing roads. Areas where roads and operable forests are well separated from winter range units, such as the Kitkiata, Olh, and Hevenor LUs, the road-related disturbance is less than 20%. Areas where the THLB and winter range units are close together, usually where valleys are steep and narrow, such as the Kitsault, Bishop and Quottoon LUs, road-related disturbances are greater than 50%. No patterns were identified between the ecosection and the amount of road related disturbance. See Appendix 2 for the complete results of all indicators used.

4.2 Risk Assessment

In total, the risk indicators were available for 33 of the LUs within the NC LRMP study area. When run through the belief network, 15 LUs were considered a very low risk, 16 were considered a low risk, and two were considered a moderate risk. See Table 2 for a complete listing of the risks of retaining the base case circumstances.

Table 2: Risk assessment results for LUs with available data. Note the error associated with each risk value.

LU	Risk Class	Risk Value	Error	Comments
Anyox	Very Low	0.13	0.10	
Belle_Bay	Low	0.20	0.17	
Big_Falls	Low	0.24	0.19	
Bishop	Low	0.24	0.19	
Brown	Very Low	0.15	0.12	
Chambers	Low	0.21	0.17	
Gribbell	Low	0.36	0.22	Assessed as HEL due to isolation
Hartley	Low	0.22	0.16	
Hawkes_South	Low	0.35	0.21	Assessed as HEL due to isolation
Hevenor	Low	0.22	0.16	
Johnston	Very Low	0.14	0.12	
Kaien	Low	0.36	0.22	
Khtada	Very Low	0.15	0.12	
Khutzeymateen	Very Low	0.11	0.07	Area is protected from development
Khyex	Very Low	0.15	0.12	
Kitkiata	Very Low	0.10	0.07	
Kitsault	Moderate	0.51	0.23	
Kshwan	Very Low	0.12	0.10	
Kumealon	Low	0.33	0.21	
Kwinamass	Very Low	0.14	0.12	
Marmot	Low	0.23	0.18	
Observatory_West	Very Low	0.12	0.08	
Olh	Very Low	0.13	0.10	
Pa_aat	Moderate	0.45	0.21	
Quottoon	Low	0.24	0.19	
Red_Bluff	Low	0.33	0.21	
Scotia	Very Low	0.14	0.12	
Skeena_Islands	Very Low	0.15	0.12	
Somerville	Low	0.30	0.22	
Sparkling	Very Low	0.15	0.12	

Stagoo	Very Low	0.18	0.12	
Triumph	Low	0.22	0.18	
Union	Low	0.33	0.21	

5.0 Discussion and Conclusions

5.1 Indicators

The calculated RONV for forest cover within winter range units indicates that most wintering areas have less forest cover compared to the overall NC LRMP area average for forested ecosystems. This agrees with intuitive estimations of the cover given that winter range will often include areas of disturbance. A literature review indicates that most forests in the NC LRMP area are subject to small stand or individual tree level disturbances under natural conditions (Dorner and Wong, 2002). However, areas where mountain goats winter are generally steep, include exposed rock, and have southern exposures. Consequently, they are more often subject to avalanches, colluvial disturbances, wind events, and even fire. This may be evident in the lower average forest cover and higher standard deviations found in the KIR ecosection where steeper and drier slopes predominate.

A comparison of the RONV with the reduction in forest cover associated with harvesting suggests that harvesting will not drive forest cover below one standard deviation from the average in more than 3 cases of the 33 LUs examined. While additional factors are considered in the risk assessment, this strongly indicates that on a habitat capability scale alone, impacts will not be significant and will be largely within the RONV at both a LU and a District scale. The three LUs with harvesting greater than an ecosection standard deviation include the Kitsault LU in the MEM ecosection, and the Bishop and Somerville LUs in the KIR ecosections.

It is more difficult to quantify the impact of increasing disturbance associated with increased road traffic. The relative values range from 0% in undeveloped areas with no planned harvesting, such as the Anyox and Khutzeymateen LUs, to 59% and 66% in the Quottoon and Kitsault LUs, respectively. These highly rated LUs have a few geographic characteristics in common including narrow watersheds, winter range units near the access point in the LU, and east-west valleys with little forest cover on the north aspect slopes. The narrow watersheds force mainline access into the mid-slopes where the 300 m band can include large areas of winter range upslope. Due to the cumulative method employed by SELES, winter range near an access point gets repeatedly counted every time harvesting is done anywhere in the LU. A good example is in the Bishop LU where there are large areas of winter range directly upslope from the first few kilometres of mainline. The incidence of high density east-west valley concentration likely occurs in several LUs. The Kitsault, however, has a compounding factor of few forests on north aspects. Consequently, within this LU road construction will occur almost exclusively on the south aspect slope where the vast majority of winter range units have been identified.

While the indicator for road related disturbance provides some measure of increased rates of disturbance, the results should not be interpreted literally. For example, in the Big Falls LU the road associated disturbance indicator is 56%. This could be the result of the same 4.6 ha being disturbed every year over the 250 year rotation. Alternatively, this could be the result of 550 ha throughout the LU being disturbed twice in the 250 year rotation. Differentiating these two scenarios is impossible with the existing assessment process. Given the difficulty interpreting the impact of the road related disturbance indicator, a standard rate of impact was set as an increase in 0.1 risk mark, with broad error probabilities, for every road related disturbance class.

5.2 Risk Assessment

In general, this risk assessment indicates that the risk to mountain goat winter range of maintaining the existing development strategies is very low or low in most LUs. The outputs for the risk model for the entire NC LRMP area indicated only two areas, the Kitsault and the Pa-aat LUs, that have moderate risks associated with maintaining forest management in its current state. The Kitsault LU justifies this level of risk with 25% of the identified winter range falling within the THLB. In some areas, harvesting in the 1970’s has already resulted in lost snow interception in winter range. The road associated disturbance indicator is also ranked as the highest of all watersheds and possible mining operations in the watershed could increase the rate of disturbance dramatically. Finally, the MEM ecosection generally has reasonable quality winter range habitat but is relatively isolated from immigration sources and the individual population centres have fewer mountain goats due to high snow loading. Consequently, decreased winter range and increased human access could have significant impacts on the populations in this LU.

The Pa-aat LU is a different circumstance in that there is a no overlap between the THLB and identified winter range. Only 48 ha of winter range were identified in the Pa-aat LU during winter range mapping. However, the road associated disturbance indicator is ranked very high and the LU occurs within the HEL where populations are generally smaller, more isolated, and less productive compared to other ecosections. Given the amount of road disturbance, there is a moderate probability that goats could be significantly impacted in this LU.

As indicated, the remaining 31 LUs are rated either very low or low risk following this process. However, it should be noted that due to uncertainties in associations, an error value is generated for each risk value (see Table 2). These error ratings provide a range of uncertainty around the value and should be considered within the context of the risk ratings provided. For example, the Kumealon LU has a risk value of 0.33 which falls within the low risk class. However, the error value is stated as 0.21. This suggests that the actual risk is between 0.12 (very low) and 0.54 (moderate). These ranges of risk should be considered in evaluating management scenarios.

5.3 Uncertainties

This risk assessment incorporates several of the most significant factors for assessing the risks that continuing current management practices will impact mountain goats. While not considered in this assessment, there are several factors that could further impact the level of risk. First, the most significant factors in long term survival of mountain goats include quality of habitat, population size, and potential for immigration. These factors have been incorporated at a general level by considering general patterns at an ecosection scale. Detailed data are not available to adequately address these at a LU scale. Second, the difference between helicopter harvesting and ground based harvesting was not considered. This has potential significance because helicopter harvesting could significantly increase level of disturbance and could access wood that would normally be unavailable to ground based methods. Finally, this assessment does not incorporate the impact of retaining forested areas within the THLB such as riparian management areas and wildlife tree patches (WTP). While it is unlikely that riparian management areas will result in a significant impact on total forested winter range, it is likely that some WTP will be retained in goat winter range. Given the difficulty harvesting in these steep areas, it is likely that an additional 5-10% of goat winter range within the THLB would be retained in WTP throughout the study area.

5.4 Impact Mitigation

Reducing the impact of current harvesting practices would require addressing one or both of: (a) reduction in snow interception in winter range areas, or (b) the increased human access created by expanding road networks. Managing for a longer rotation in winter range would allow the recovery of some snow interception properties. However, given the extended time for recovery in goat winter range, it is unlikely that significant increases in habitat would be achieved. At a more localized scale, individual site inspections of the area would likely identify key areas of use and important seasonal movement routes that could be subsequently incorporated into stand specific management plans. At a stand level, these specific treatments could reduce impacts to mountain goats within THLB. Similar site-specific mitigation could be accomplished through selective location of mainlines and spurs near winter range. The retention of forested buffers adjacent to the mainline around winter range units could further reduce the potential for access related disturbance by making winter range more difficult to see and reducing sound-associated disturbances. Finally, while not considered in this risk assessment, management of helicopter access in the winter, either recreational or logging related, would limit interference with goats during the most sensitive times of the year.

Finally, the method employed was designed to provide results at a scale suitable for an analysis of LUs. It does not provide results suitable for interpretation at a stand scale. For example, while the level of risk is very low for the Johnson LU, individual winter range units could be completely harvested and roaded. The assessment procedure does not analyse the data at a spatial explicit scale suitable for evaluating individual winter range units. Adjustment to the assessment process can be incorporated for future scenario modelling to address this issue, but may not be cost effective given the results of this risk assessment.

6.0 References

Caufield, J.E., L.J. Lyon, J.M. Hillis, and M.J. Thompson. 1999. Ungulates. Pages 6.1-6.25 *in* G. Joslin and H. Youmans, coordinators. Effects of recreation on Rocky Mountain wildlife: A review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of the Wildlife Society. 307pp.

Chadwick, D.H. 1983. A beast the color of winter. San Francisco: Sierra Club Books. 208 pp.

Cote, S.D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin **24**: 681-685.

Del Frate, G.G., and T.H. Spraker. 1994. The success of mountain goat management on the Kenai Peninsula in Alaska. In Proceedings of the Ninth Biennial Symposium of the Northern Wild Sheep and Goat Council, *Ed*. M. Pybus, Cranbrook, British Columbia. **9**:92-98.

Dorner, B. and C. Wong, 2002. Background Report – Natural Disturbance Dynamics on the North Coast, Ministry of Sustainable Resource Management – Skeena Region. January 2002. 44 pp.

Foster, B.R. 1982. Observability and habitat characteristics of the mountain goat (*Oreamnos americanus* Blainville, 1816) in West-Central British Columbia. Masters Thesis: University of British Columbia. 134pp.

Foster, B.R. and E.Y. Rahs. 1985. A study of canyon-dwelling mountain goats in relation to proposed hydro-electric development in Northwestern British Columbia, Canada. *in* Biological Conservation **33** pp. 209-228.

Fox, J.L. 1983. Constraints on winter habitat selection by mountain goats (*Oreamnos americanus*) in Alaska. Seattle: College of Forest Resources, University of Washington; 147 pg. PH. D. dissertation.

Fox, J.L. and C.A. Smith. 1988. Winter mountain goat diets in southeast Alaska. J. Wildl. Manage. **52(2)**:362-365.

Fox, J.L., C.A. Smith, and J.W. Schoen. 1989. Relation between mountain goats and their habitat in southeastern Alaska. U.S. For, Serv., Gen. Tech. Rep. PNW-246. 25 pp.

Gilbert, B.A. and K.J. Raedeke. 1992. Winter habitat selection of mountain goats in the north Tolt and Mine Creek drainages of the north central Cascades. In Biennial Symposium of the Northern Wild Sheep and Goat Council, Cody, Wyoming. **eds**. J. Emmerich and W.G. Hepworth. Wyoming Game and Fish Department, Cody. **8**:305-324

Hatter, I. 2002. Effects of harvesting small mountain goat populations. Presentation to the Nass Wildlife Committee. Ministry of Water Land and Air Protection, Biodiversity Branch, Victoria.

Hebert, D.M. and W.G. Turnbull. 1977. A description of southern interior and coastal mountain goat ecotypes in British Columbia. In W. Samuel and W.G. Macgregor **eds**. Proceedings, First International Mountain Goat Symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 126-146.

Hjeljord, O. 1973. Mountain goat forage and habitat preference in Alaska. J. Wildl. Manage. **37(3)**:353-362.

Horn H. and D. Stoffels. 2002. North Coast Land and Resource Management Plan: Map and Inventory Handbook. Ministry of Sustainable Resource Management – Skeena Region. January 2002. 94 pp.

Johnson, R.L. 1977. Distribution, abundance and management status of mountain goats in North America. *in* Proceedings of the First International Mountain Goat Symposium **1** pp1-7.

Joslin, G.L. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain front. Bienn. Symp. North Wildl Sheep and Goat Counc. 5:253-271

Krausman, P.R. 1997. Regional Summary. Pp. 316-317 in: D.M Shakleton (*ed*).Wild Sheep and Goats, and their Relatives: Status Survey and Conservation Action Plan for Caprinae. IUCN, Gland, Switzerland and Cambridge, UK.

Macgregor, W.C. 1977. Status of mountain goats in British Columbia. In W. Samuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 24-28.

McCrory, W.P. and D.A. Blood. 1977. Mountain goat surveys in Yoho National Park, British Columbia. In W. Samuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 69-73.

NatureServe Explorer: An online encyclopedia of life [web application]. 2001. Version 1.6. Arlington, Virginia, USA: NatureServe. Available: http://www.natureserve.org/explorer. (Accessed June 17, 2002).

Penner, D.F. 1988. Behavioral response and habituation of mountain goats in relation to petroleum exploration at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild sheep and Goat Council. **6**: 141-158.

Petocz, R.G. 1973. The effect of snow cover on the social behaviour of bighorn rams and mountain goats. Can J. Zool. **51**: 987-993

Poole, K.G. and G. Mowat. 1997. Mountain goat winter habitat requirements in the West Kootenay region of British Columbia. Unpubl. Rep. For Slocan Forest Products Ltd. Slocan, British Columbia. 22 pp.

Pollard, B.T. 2002. Mountain goat winter range mapping for the North Coast Forest District. Contracted report for the North Coast Land and Resource Planning Team. Smithers, BC, pp. 30 with 130 attached maps.

Schoen, J.W., M.D. Kirchhoff, and O.C. Walmo. 1980. Winter habitat use by mountain goats. Juneau, Alaska Department of Fish and Game; Federal Aid in Wildlife Restoration Project W-17-10, 11 and W-21-1,2; final report; job 12.4R. 67pp.

Schoen, J.W. and M.D. Kirchhoff. 1982. Habitat use by mountain goats in southeast Alaska. Juneau, AK: Alaska Department of Fish and Game; Federal Aid in Wildlife Restoration Project W-17-10, 11 and W-21-1, 2; final report; job 12.4R. 67 p.

Smith, B.L. 1977. Influence of snow conditions on winter distribution, habitat use, and groups size of mountain goats. In W. Samuel and W.G. Macgregor **eds**. Proceedings, First international mountain goat symposium; 1977 February 19; Kalispell, MT. Victoria, BC: Province of British Columbia Ministry of Recreation and Conservation, Fish and Wildlife Branch: 174-189.

Smith, C.A. 1986. Habitat use by mountain goats in southeastern Alaska. Juneau, AK: Alaska Department of Fish and Game; Federal Aid in Wildlife Restoration Project W-22-2; final report; job 12.4R. 58p.

Smith, C.A. 1994. Evaluation of a multivariate model of mountain goat winter habitat selection. In Proceedings of the Ninth Biennial Symposium of the Northern Wild Sheep and Goat Council, *Ed*. M. Pybus, Cranbrook, British Columbia. **9**:159-165.

Smith, C.A. and K.J. Raedeke. 1982. Group size and movements of a dispersed low density goat population, with comments on inbreeding and human impacts. Proceedings, Biennial Symposium Northern Wild Sheep and Goat Council; 1984, April 30-May 3; Whitehorse, YT. Yukon Wildlife Branch. **3**: 54-67.

Appendix 1: Relational Tables and Probabilities In Mountain Goat Risk Network

Delta Thermal

Future Forest Percentage	Initial Forest Percentage	NSC[*1]	SL Decrease	Mod Decrease	High Decrease
Reduced less than 8%	Reduced less than 25%	0.25	0.5	0.25	0
Reduced less than 8%	Reduced between 25 and 49%	0.3	0.6	0.1	0
Reduced less than 8%	Reduced between 50 and 74%	0.4	0.55	0.05	0
Reduced less than 8%	Reduced greater than 75%	0.6	0.4	0	0
Reduced between 8 and 15%	Reduced less than 25%	0.05	0.25	0.5	0.2
Reduced between 8 and 15%	Reduced between 25 and 49%	0.15	0.25	0.5	0.1
Reduced between 8 and 15%	Reduced between 50 and 74%	0.3	0.5	0.2	0
Reduced between 8 and 15%	Reduced greater than 75%	0.4	0.55	0.05	0
Reduced greater than 15%	Reduced less than 25%	0	0.1	0.25	0.65
Reduced greater than 15%	Reduced between 25 and 49%	0.05	0.25	0.5	0.2
Reduced greater than 15%	Reduced between 50 and 74%	0.1	0.3	0.3	0.3
Reduced greater than 15%	Reduced greater than 75%	0.2	0.4	0.3	0.1

LU Population Impacts

Ecosection	Delta Thermal	Road Related Disturbance	None	Low	Mod	High	V.High
Hecate Lowlands	NSC	less than 10%	0.8	0.15	0.05	0	0
Hecate Lowlands	NSC	between 10 and 24%	0.7	0.2	0.1	0	0
Hecate Lowlands	NSC	between 25 and 50%	0.5	0.3	0.15	0.05	0
Hecate Lowlands	NSC	greater than 50%	0.25	0.5	0.2	0.05	0
Hecate Lowlands	Slight Decrease	less than 10%	0.6	0.3	0.1	0	0
Hecate Lowlands	Slight Decrease	between 10 and 24%	0.5	0.35	0.15	0	0
Hecate Lowlands	Slight Decrease	between 25 and 50%	0.25	0.3	0.3	0.15	0
Hecate Lowlands	Slight Decrease	greater than 50%	0.05	0.25	0.45	0.2	0.05
Hecate Lowlands	Moderate Decrease	less than 10%	0.3	0.4	0.2	0.1	0
Hecate Lowlands	Moderate Decrease	between 10 and 24%	0.15	0.3	0.35	0.15	0.05
Hecate Lowlands	Moderate Decrease	between 25 and 50%	0.05	0.2	0.5	0.2	0.05
Hecate Lowlands	Moderate Decrease	greater than 50%	0	0.15	0.35	0.4	0.1
Hecate Lowlands	High Decrease	less than 10%	0.15	0.25	0.45	0.15	0
Hecate Lowlands	High Decrease	between 10 and 24%	0.05	0.2	0.5	0.2	0.05
Hecate Lowlands	High Decrease	between 25 and 50%	0	0.1	0.35	0.45	0.1
Hecate Lowlands	High Decrease	greater than 50%	0	0.1	0.2	0.35	0.35
Meziadin Mountains	NSC	less than 10%	0.9	0.1	0	0	0
Meziadin Mountains	NSC	between 10 and 24%	0.8	0.15	0.05	0	0
Meziadin Mountains	NSC	between 25 and 50%	0.6	0.25	0.15	0	0
Meziadin Mountains	NSC	greater than 50%	0.4	0.4	0.15	0.05	0
Meziadin Mountains	Slight Decrease	less than 10%	0.8	0.15	0.05	0	0
Meziadin Mountains	Slight Decrease	between 10 and 24%	0.6	0.25	0.15	0	0
Meziadin Mountains	Slight Decrease	between 25 and 50%	0.4	0.4	0.15	0.05	0
Meziadin Mountains	Slight Decrease	greater than 50%	0.15	0.35	0.35	0.15	0
Meziadin Mountains	Moderate Decrease	less than 10%	0.6	0.25	0.15	0	0
Meziadin Mountains	Moderate Decrease	between 10 and 24%	0.4	0.4	0.15	0.05	0
Meziadin Mountains	Moderate Decrease	between 25 and 50%	0.15	0.35	0.35	0.15	0
Meziadin Mountains	Moderate Decrease	greater than 50%	0	0.2	0.5	0.2	0.1
Meziadin Mountains	High Decrease	less than 10%	0.15	0.35	0.35	0.15	0
Meziadin Mountains	High Decrease	between 10 and 24%	0	0.2	0.5	0.2	0.1
Meziadin Mountains	High Decrease	between 25 and 50%	0	0.15	0.35	0.4	0.1
Meziadin Mountains	High Decrease	greater than 50%	0	0.1	0.25	0.35	0.3
Southern Boundary Ranges	NSC	less than 10%	0.95	0.05	0	0	0
Southern Boundary Ranges	NSC	between 10 and 24%	0.9	0.1	0	0	0
Ecosection	**Delta Thermal**	**Road Related Disturbance**	**None**	**Low**	**Mod**	**High**	**V.High**
Southern Boundary Ranges	NSC	between 25 and 50%	0.8	0.15	0.05	0	0
Southern Boundary Ranges	NSC	greater than 50%	0.6	0.25	0.1	0.05	0
Southern Boundary Ranges	Slight Decrease	less than 10%	0.9	0.075	0.025	0	0

Southern Boundary Ranges	Slight Decrease	between 10 and 24%	0.8	0.15	0.05	0	0
Southern Boundary Ranges	Slight Decrease	between 25 and 50%	0.6	0.25	0.1	0.05	0
Southern Boundary Ranges	Slight Decrease	greater than 50%	0.2	0.35	0.35	0.1	0
Southern Boundary Ranges	Moderate Decrease	less than 10%	0.8	0.15	0.05	0	0
Southern Boundary Ranges	Moderate Decrease	between 10 and 24%	0.6	0.25	0.1	0.05	0
Southern Boundary Ranges	Moderate Decrease	between 25 and 50%	0.2	0.35	0.35	0.1	0
Southern Boundary Ranges	Moderate Decrease	greater than 50%	0.05	0.2	0.4	0.25	0.1
Southern Boundary Ranges	High Decrease	less than 10%	0.6	0.25	0.1	0.05	0
Southern Boundary Ranges	High Decrease	between 10 and 24%	0.2	0.35	0.35	0.1	0
Southern Boundary Ranges	High Decrease	between 25 and 50%	0.05	0.2	0.4	0.25	0.1
Southern Boundary Ranges	High Decrease	greater than 50%	0	0.1	0.3	0.4	0.2
Kitimat Ranges	NSC	less than 10%	0.975	0.025	0	0	0
Kitimat Ranges	NSC	between 10 and 24%	0.95	0.05	0	0	0
Kitimat Ranges	NSC	between 25 and 50%	0.9	0.1	0	0	0
Kitimat Ranges	NSC	greater than 50%	0.8	0.15	0.05	0	0
Kitimat Ranges	Slight Decrease	less than 10%	0.95	0.05	0	0	0
Kitimat Ranges	Slight Decrease	between 10 and 24%	0.9	0.1	0	0	0
Kitimat Ranges	Slight Decrease	between 25 and 50%	0.8	0.15	0.05	0	0
Kitimat Ranges	Slight Decrease	greater than 50%	0.5	0.35	0.1	0.05	0
Kitimat Ranges	Moderate Decrease	less than 10%	0.9	0.1	0	0	0
Kitimat Ranges	Moderate Decrease	between 10 and 24%	0.8	0.15	0.05	0	0
Kitimat Ranges	Moderate Decrease	between 25 and 50%	0.5	0.35	0.1	0.05	0
Kitimat Ranges	Moderate Decrease	greater than 50%	0.2	0.3	0.35	0.1	0.05
Kitimat Ranges	High Decrease	less than 10%	0.8	0.15	0.05	0	0
Kitimat Ranges	High Decrease	between 10 and 24%	0.5	0.35	0.1	0.05	0
Kitimat Ranges	High Decrease	between 25 and 50%	0.2	0.3	0.35	0.1	0.05
Kitimat Ranges	High Decrease	greater than 50%	0.05	0.2	0.3	0.35	0.1

*1 - NSC-No Significant Change

Appendix 2. Complete Data Set of Indicators for Mountain Goat Risk Assessment

Landscape Unit	Ecosection	Initial Forest Percentage	Future Forest Percentage	Road Related Disturbance [*1]
Anyox	SBR	16%	16%	0.00%
Aristazabal	HEL	No Goat Winter Range Identified		
Banks	HEL	No Goat Winter Range Identified		
Belle_Bay	SBR	71%	67%	26%
Big_Falls	KIR	65%	56%	56%
Bishop	KIR	72%	58%	58%
Brown	KIR	39%	35%	37%
Campania	HEL	No Goat Winter Range Identified		
Captain	HEL	No Goat Winter Range Identified		
Chambers	KIR	77%	66%	51%
Chapple	HEL	Outside Scope of Winter Range Mapping Project		
Dundas	HEL	No Goat Winter Range Identified		
Gill	HEL	No Goat Winter Range Identified		
Greenville	SBR	Outside Scope of Winter Range Mapping Project		
Gribbell	KIR	51%	43%	45%
Hartley	HEL	54%	50%	21%
Hawkes_South	KIR	47%	45%	31%
Helmcken	HEL	No Goat Winter Range Identified		
Hevenor	HEL	60%	57%	19%
Iknouk	SBR	Outside Scope of Winter Range Mapping Project		
Johnston	KIR	51%	49%	31%
Kaien	HEL	62%	51%	42%
Khtada	KIR	41%	36%	35%
Khutzeymateen	KIR	51%	51%	2%
Khyex	KIR	43%	41%	36%
Kiltuish	KIR	Outside Scope of Winter Range Mapping Project		
Kitkiata	KIR	37%	37%	3%
Kitsault	MEM	73%	48%	66%
Klekane	KIR	Outside Scope of Winter Range Mapping Project		
Kshwan	SBR	43%	43%	0%
Kumealon	HEL	61%	59%	30%
Kwinamass	KIR	59%	53%	34%
Laredo	HEL	No Goat Winter Range Identified		
Marmot	SBR	64%	54%	33%
McCauley	HEL	No Goat Winter Range Identified		
Monckton	HEL	No Goat Winter Range Identified		
Nass	SBR	Outside Scope of Winter Range Mapping Project		
Observatory_East	SBR	No Goat Winter Range Identified		
Observatory_West	SBR	79%	79%	2%
Olh	SBR	49%	49%	6%
Pa_aat	HEL	40%	40%	57%
Pearse	SBR	No Winter Range Identified		
Porcher	HEL	No Winter Range Identified		
Quottoon	KIR	62%	52%	59%
Red_Bluff	HEL	68%	64%	26%
Scotia	KIR	71%	65%	37%
Skeena_Islands	KIR	40%	40%	26%
Somerville	KIR	82%	63%	54%
Sparkling	KIR	29%	25%	43%
Stagoo	SBR	80%	77%	29%
Stephens	HEL	No Winter Range Identified		
Surf	HEL	Outside Scope of Winter Range Mapping Project		
Tolmie	HEL	Outside Scope of Winter Range Mapping Project		
Triumph	KIR	48%	39%	48%
Trutch	HEL	Outside Scope of Winter Range Mapping Project		
Tuck	HEL	No Winter Range Identified		
Union	HEL	73%	69%	40%
Whalen	HEL	Outside Scope of Winter Range Mapping Project		

[1*] Expressed as a percent of total available mountain goat winter range.