Terrestrial Ecosystem Mapping (TEM) with Wildlife Habitat Interpretations for the Akie and Pesika Landscape Units of the Mackenzie Timber Supply Area:

Volume 2 - Wildlife

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Executive Summary

During 1996 to 2000, KTPW-Geo Consortium (currently composed of Bio-Geo Dynamics Ltd., Taiga-Pacific GIS Ltd., Taiga-Pacific Ltd., R.A. Sims and Associates Ltd., and Ray Wehr) completed a project on Terrestrial Ecosystem Mapping (TEM) with wildlife habitat interpretations for Slocan Forest Products–Mackenzie Division.

Work focused on the production of TEM and derivative wildlife suitability mapping for some fifty-three 1:20,000 mapsheets in the Akie, Pesika and Lower Ingenika Landscape Units. This Final Report documents the TEM (Volume 1) and wildlife interpretations (Volume 2) components of the project for the Akie and Pesika Landscape Units only.

TEM Mapping

TEM mapping was conducted in two stages. First bioterrain typing was completed. The bioterrain information then served as a basis for interpreting and typing ecosystems.

The bioterrain map was constructed using a two-step approach. First, terrain / landform units were identified, delineated and labelled onto 1:15,000 scale black and white photos. Terrain stability mapping was undertaken concurrently in portions of the Akie River and Pesika Creek drainages, and this initial terrain / landform layer was also used as a complementary base for that mapping. For the purposes of TEM and associated wildlife habitat suitability interpretations, bioterrain enhancements were then photo-interpreted and added, including drainage class, slope steepness class, bedrock subclass, geomorphological subclass and avalanche process subclass.

TEM depicts ecosystem (site series) patterns within different Biogeoclimatic units. Within the study area, there are six different Biogeoclimatic units ranging a lower elevation boreal forest unit to high elevation non-forested alpine tundra. Each Biogeoclimatic unit included a number of site series. These included previously unclassified non-forested units as part of the current study. These unclassified units were sufficiently described so that they could be added into the provincial listings of site series. Each site series was further described using ecosystem site modifiers. Site modifiers are site-specific factors that can be directly related to management interpretations of different site series. These include factors such as aspect, soil texture, depth and certain specific soil terrain features.

Bioterrain and TEM databases and maps were produced through a sequence of :

- Initial field reconnaissance;
- Initial photo-typing, photo-to-map transfer, and GIS database / map production;
- Field verification sampling; and,
- Final photo-typing, photo-to-map transfer, and GIS database / map production.

Methods followed and other specifications are detailed in Volume 1. The work conforms to provincial standards for TEM mapping (RIC, 1996, 1997) and standard conventions were

followed throughout the process. Final TEM products were prepared for hard-copy presentation, but are also completed in digital form, within a GIS.

Each stage of TEM map production was accompanied by a combination of internal and external quality control audits. The latter were conducted under the auspices of MELP Provincial Correlation staff for TEM, and formal approvals and sign-offs at milestones were obtained throughout the project.

There were two additional ecological studies supplementary to the TEM component: 1) Wetland description and stratigraphy and 2) Mensuration studies of Pacific Willow. These two projects provided in-depth investigation of two poorly-understood components of the study area.

Wildlife Habitat Interpretations

The goal of the wildlife component was to produce habitat suitability interpretations for eleven featured wildlife species: American marten, fisher, lynx, grizzly bear, elk, caribou, moose, Stone sheep, mountain goat, wolverine, and northern Goshawk. In addition to habitat suitability mapping, this project provides a synthesis of known wildlife values for the study area, including the results of aerial surveys, wildlife habitat assessments and incidental observations.

Wildlife habitat suitability ratings define the relative importance of mapped ecological units to wildlife populations. Habitat suitability mapping provides a basis to evaluate the effects of development on wildlife habitat. It identifies areas that provide regionally and/or provincially significant habitat and places the loss or modification of habitat into a local and regional context. When combined with current known animal distributions, interpretations can also be made on potential avenues or opportunities for range expansion.

We developed species-habitat models that relate each species' life requisites to the attributes of the ecosystem units present in the study area. Each model is based on scientific literature, previous studies in the region, our own field data collection, additional field observations, and expert opinion. Ratings tables were generated using a linear model that contains the key attributes of ecosystem units. An automated approach using a relational database was used to assign ratings to each possible ecosystem unit in the study area. Polygon ratings were generated by "looking-up" the ecosystem unit in the ratings table. A GIS algorithm was then constructed to apply spatial adjustments to the polygon ratings for some of the species.

Based on the 1:20,000 TEM outputs, wildlife habitat suitability mapping was produced mainly in digital form, although some selected sets of 1:20,000 mapsheets were produced, for demonstration purposes, in hard copy form.

The information derived from GIS map products and associated databases of the bioterrain, TEM and wildlife habitat suitability maps can all be used to direct and inform higher-level resource management planning and operational activities.

To better understand spatial patterns of wildlife movement in the study area, a separate study on the characterisation of wildlife trails was completed as a supplementary component to the wildlife habitat interpretations.

Acknowledgements

KTPW-Geo would like to acknowledge the following individuals for their contributions and support throughout the project:

Staff of Slocan-Mackenzie provided ongoing direction and input: Scott McNay, Leslie Yaremko, and Al Balisky. The summer field crews stayed at Slocan's field camps, and Slocan provided additional help with logistics and operational support that were critical to the success of the project.

Bob Maxwell (Bioterrain Specialist, MELP, Victoria), who correlated the bioterrain mapping and the digital database, Ted Lea (Vegetation Ecologist, MELP, Victoria) and Craig Delong (Regional Ecologist, Ministry of Forests (MoF), Prince George Forest Region) who jointly correlated the ecosystem units and mapping, and Andy Stewart (Wildlife Specialist, MELP, Victoria) who correlated the wildlife habitat interpretations component.

Key external quality control auditors included Corey Erwin (TEM mapping), Barb Von Sacken (TEM mapping), Tim Brierley (spatial database), Terry Gunning (non-spatial database) and Wayne Blashill (field sampling and Venus database).

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We are pleased to acknowledge the following KTPW-Geo staff for their contributions towards the completion of the photo-typing, GIS database and support, fieldwork, final maps, wildlife interpretations, the preparation of the Final Reports:

- Angus McLeod (Project Manager) coordinated and supervised the project.

- Ecosystem mapping for the study was overseen by Ken Simonar (Bio-Geo Dynamics Ltd.).

- Summer field work was completed by several 2 and 3-person crews. Each crew provided field expertise in vegetation ecology, soil science and wildlife ecology. Vegetation ecologists were, Ken Simonar, Howard DeLong, Dan Bernier, Sharlene Becker, Wayne Lambkin, Michael Hochachka, Dr. Saphida Migabo, Marian McLellan and John Grods. Soil and terrain specialists were Dr. Zongyou Lu, Marc St. Arnaud, Ray Wehr, Tiffany Fraser, Brendan Miller, Ken Simonar and Joe Fitzpatrick. Wildlife ecologists were Jeff Matheson, Tim Janes, Rachelle Robitaille, Allister Mackenzie, Madeline Austen and Dr. Saphida Migabo

- In the office, photo-interpretation activities were undertaken by the following personnel: Bioterrain phototyping and ecosystem annotation work was undertaken by Ken Simonar, Dr. Zongyou Lu, Marc St. Arnaud, Ray Wehr, Howard DeLong, Dan Bernier, Sharlene Becker, Wayne Lambkin, Michael Hochachka, Dr. Saphida Migabo, Marian McLellan, Tiffany Fraser and Brendan Miller.

- Shudao Ni (Taiga-Pacific GIS Ltd.) coordinated the GIS portion of the ecosystem mapping component. He was ably assisted by Zhilli Wang, Ping Bai, Jing Shao, Chris Curry, and Karren Warrendorf.

- Richard Sims (RA Sims and Associates Ltd., EBA Engineering Consultants Ltd.) supervised the wildlife habitat interpretations component of the work. Jeff Matheson prepared wildlife habitat interpretations for the project. Habitat models were developed by Jeff Matheson, with the assistance of Tim Janes, Libor Michalak and Rachelle Robitaille. Christine Curry prepared and applied the GIS-based wildlife habitat algorithms. The final wildlife report was edited by Jeff Matheson and Richard Sims.

- The assembly of the final report was completed by Ken Simonar, Dan Bernier and Dr. Saphida Migabo edited the ecosystem unit description factsheets and the expanded ecosystem legend. Richard Sims, Ken Simonar, Angus McLeod and Shudao Ni supervised and edited the report production.

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1.0 INTRODUCTION

This Final Report was prepared by KTPW-Geo for Slocan Forest Products Ltd.-Mackenzie Division, and describes ***Terrestrial Ecosystem Mapping (TEM) with Wildlife Habitat Interpretations for the Akie and Pesika Landscape Units of the Mackenzie Timber Supply Block (TSA)***[1].

The Final Report is contained in two volumes: Volume 1: TEM; and, Volume 2: Wildlife.

1.1 Background

KTPW-GEO Consortium undertook this project. KTPW-Geo is a consortium of consulting companies, composed of Bio-Geo Dynamics Ltd., Taiga Pacific (formerly Kuwani Forestry Consulting Ltd.), Taiga Pacific GIS Ltd., R.A. Sims and Associates (formerly Geomatics International Inc.), EBA Engineering Ltd. and Ray Wehr. This strong multidisciplinary group joined the talents of experts in ecology, terrain, wildlife and GIS mapping for a common purpose.

Project tasks were assigned among the member companies in KTPW-Geo as follows:

1. *Field Sampling, Ecosystem Analysis and Photo-Interpretation of Bioterrain and Ecosystem Units* was primarily undertaken by Bio-Geo Dynamics Ltd.. Field sampling was assisted by RA Sims and Associates Ltd. (formerly Geomatics International Inc.), Ray Wehr, and Taiga-Pacific Ltd.
2. *GIS and TEM Map Production* was directed by Taiga-Pacific GIS Ltd. with assistance from RA Sims and Associates Ltd.
3. *Wildlife Habitat Interpretations* were undertaken by RA Sims and Associates Ltd., and later, by the same personnel employed by EBA Engineering Consultants Ltd.'s Vancouver, BC office.

The project was conducted during Winter, 1996 to Spring, 2000, and was financially supported by Forest Renewal British Columbia (FRBC).

Scientific and technical direction of the work was provided by key staff within the Ministries of Forests (MOF), and Environment, Lands and Parks (MELP). Technical details of the approach were initially outlined in detail, in the project's original Technical Work Plan (KTPW-Geo, 1996).

Within BC, TEM is a standardized methodology and tool for identifying and mapping ecosystem units (Banner et al., 1996; Britton et al., 1996). TEM is based, in large part, upon the

[1] The Buffalohead Landscape Unit was identified under the original 1996 contract (with Timberwest) as a candidate area for TEM mapping, but it was later removed from the study area. Occasional reference will be made to the Buffalohead LU in parts of the reporting, since ecological conditions are closely associated to those within the study area's other Landscape Units.

Biogeoclimatic Ecosystem Classification (BGC) system (e.g., see Meidinger and Pojar, 1991; DeLong et al. 1990, 1994). To date, nearly 100 separate TEM projects have been undertaken throughout the province, using standardized protocols and methodologies, including integrated quality assurance and project correlation components.

Volume 1: TEM is composed of four main sections. First, there is an overview section providing context related to the project's objectives, scope and organization, and the study area's physiographic and biotic components (Section 1). Section 2 describes the methodology and approach followed to complete TEM and wildlife interpretation deliverables. Section 3 documents symbols and conventions used in the mapping. Section 4 is an illustrated expanded legend for all ecosystems visited, described and classified within the study area. Additional appendices and a complete TEM map folio, in digital form, also accompany this volume.

1.2 Objectives

The project's principal objective was to undertake TEM and associated wildlife habitat mapping according to Resource Inventory Committee (RIC) standards (Resource Inventory Committee 1995, 1996; Anon., 1996). It was understood that the inventory outputs of the work would be directly incorporated into Slocan's resource management and planning activities within the Mackenzie TSA.

Operational forestry requires the best possible inventory data, so that informed management planning can be undertaken. Within the study area, there are some particular concerns about preserving critical caribou, bear, moose, Stone sheep and other wildlife habitat conditions. Consequently, the current TEM project provides valuable baseline information for some fifty-three 1:20,000 mapsheets within the Mackenzie TSA.

Several sub-objectives were also outlined at the outset of the project, and were summarized in KTPW-Geo's original Technical Plan for the project (KTPW-Geo, 1996). These include:

- Confirm or adjust locations of Biogeoclimatic (BGC) zonal/sub zonal/variant boundaries within the study area;
- Refine existing site series units and their descriptions, and define / describe previously unclassified ecosystem units, particularly within the Spruce Willow Birch (SWB), Parkland, and AT zones;
- Delineate, describe and map out poorly-known wetland ecosystem units within the study area;
- Develop spatially-referenced baseline biophysical information so that it can assist higher level management analysis and decision-making (such as, longer-term wildlife management scenarios, or spatial estimation of potential site productivity within the study area; and,
- Provide data and information that are directly applicable for operational planning (such as, planning for season of harvest, locating sources of aggregate, and identifying areas of potentially unstable or erosion-prone terrain).

The goal of the wildlife component was to produce habitat suitability interpretations for eleven featured wildlife species: American marten, fisher, lynx, grizzly bear, elk, caribou, moose, Stone sheep, mountain goat, wolverine, and northern Goshawk. In addition to habitat suitability mapping, the project provides a synthesis of known wildlife values for the study area, including the results of aerial surveys, wildlife habitat assessments, and incidental observations.

Results of this project provide valuable spatially-based data and fundamental information for Slocan – Mackenzie Division's operational planning within a portion of the Mackenzie TSA. The project has also produced outputs that will directly address biodiversity conservation issues within the study area, which is known to have especially high wildlife values.

1.3 Study area

The Mackenzie TEM study area is located in north-central British Columbia, north of Williston Lake. Figure 1 shows the extent of the approximately 476,000 ha study area, as well as those TRIM mapsheets involved in the project.

The study area is located within the Mackenzie TSA and includes a contiguous block composed of approximately 47 1:20 000 TRIM mapsheets (including partial sheets) located within the following UTM coordinates: 438,670E, 6,273,310N(SE corner); 440,230E, 6,384,620N(NE corner); 328,110E, 6,276,370N(SW corner); 332,680E, 6,387,630N (NW corner).

The study area is further divided into five different Landscape Units (LUs) shown on the map representing the major drainages (Figure 1). They are: The Upper and Lower Akie River, Pesika Creek, Lower Ingenika, and Buffalohead LUs. The study area is highly variable in terms of topography, and ranges in elevation from approximately 720m to 2600m.

1.4 Physiography and Soils Summary

The Study Area straddles the Rocky Mountain Trench. The Finlay River lies in the centre of the trench and drains into the north end of Williston Reservoir. On the east side of the trench, the Study Area contains the Akie and Pesika River drainages. On the west side of the trench, significant watercourses include McGraw Creek, Tsaydiz Creek, Estella Creek, Isolla Creak and the Ingenika River.

Almost all of the eastern side of the study area occurs within the Muskwa Range Section of the Rocky Mountain Physiographic Subdivision. Narrow valleys with valley bottom fluvial and glacio-fluvial deposits occur within both the Akie and Pesika River drainages. Valley

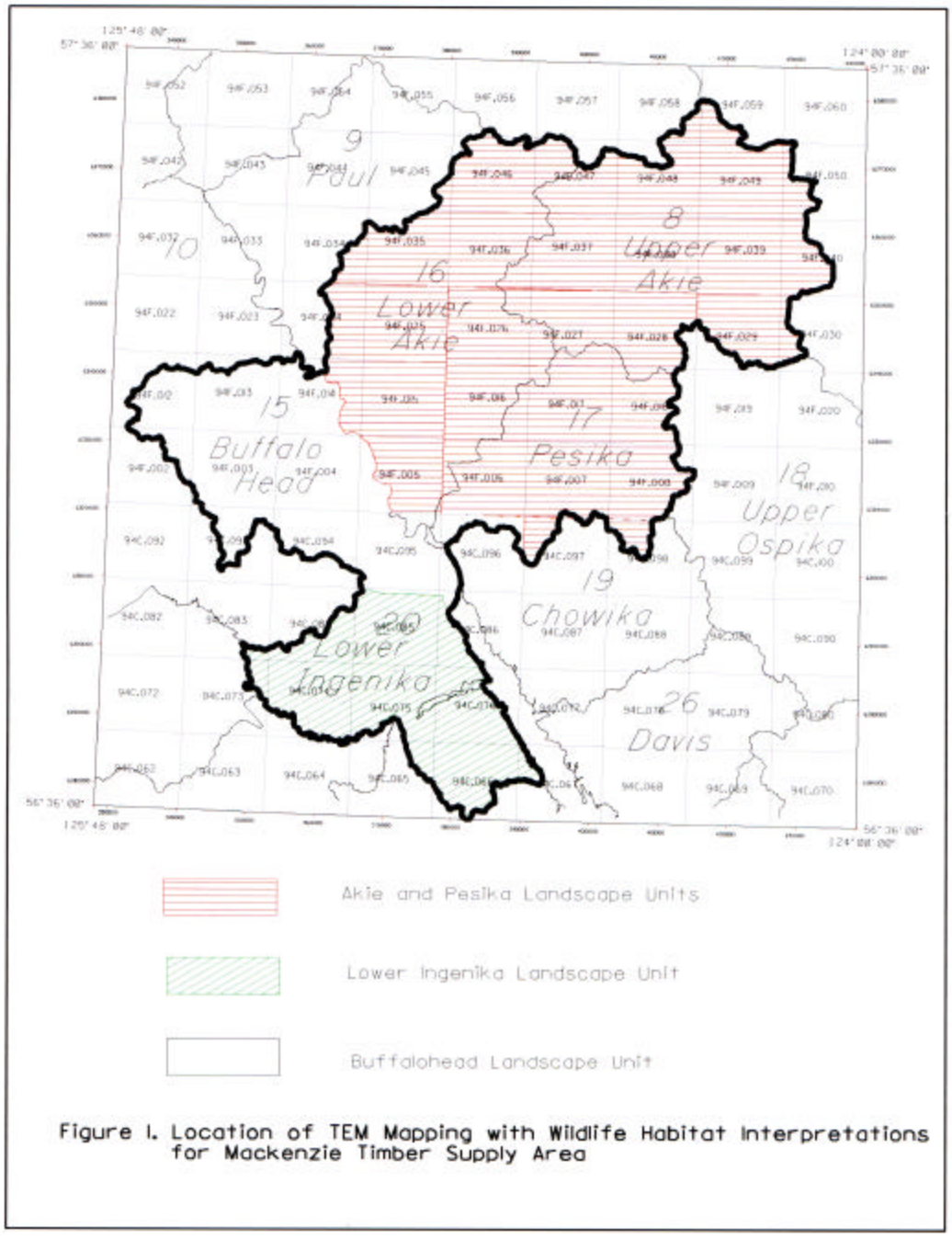

Figure 1. The Akie, Pesika and Lower Ingenika Study Area.

sides are dominated by a mixed coverage of both morainal and colluvial parent materials. Soils are Brunisolic Grey Luvisols on medium-textured morainal materials and Humo-Ferric Podzols and brunisols on coarse-textured fluvial and glacio-fluvial materials.

Lower elevations of all drainages in the study area empty into the Finlay River or Williston Lake; this central portion of the Study Area is within the Rocky Mountain Trench Subdivision of the Interior Plateau Physiographic Unit. Lower elevations are dominated by extensive areas of rolling to level, glacio-fluvial and fluvial terrain. Brunisols are the dominant soil group associated with this terrain.

The Ingenika River occurs within the Swanell and Finlay Range Physiographic Sections of the Omineca Mountains Subdivision of the Interior Plateau physiographic unit. Extensive areas of glacio-fluvial and fluvial material occur within the valley bottom. Brunisols are the dominant soils on these parent materials. Brunisolic Grey Luvisols and Brunisols both occur on upland morainal sites.

For a full description of Physiography and Soils, see Volume 1 – TEM.

1.5 Ecoregions

The study area is located within the Northern Boreal Mountains Ecoprovince. Two Ecoregions comprise the study area; the Northern Boreal Ecoregion and the Northern Rocky Mountains Ecoregion. Within the study area, subdivisions (i.e., Ecosections) of Ecoregions exist. The Cassiar Mountain Ranges Ecosection (CAR) within the Northern Boreal Mountain Ecoregion comprises the Lower Ingenika and Buffalo Head LUs east of the Finlay River.

Most of the remainder of the study area, including much of the Upper and Lower Akie River, and Pesika Creek LUs, are located within the Western Muskwa Ranges (WMR) Ecosection of the Northern Rocky Mountains Ecoregion. The Eastern Muskwa Ecosection (EMR) of the Northern Rocky Mountain Ecoregion occurs in the headwaters of the Akie and Pesika drainages.

1.6 Biogeoclimatic Units

The Boreal White and Black Spruce (BWBS) zone occurs as an extension of the Great Plains (Alberta Plateau) continental climate into the northeastern corner of BC. The zone occupies the lower elevations of the main valleys west of the northern Rocky Mountains (Table 1). The climate of this zone is characterised by short growing seasons, long, very cold winters with frequent outbursts of arctic air masses. Annual precipitation averages between 330 and 570 mm with 35-55% of this falling as snow. The ground freezes deeply for a large part of the year and discontinuous permafrost is common in the northeastern parts of the zone. White spruce, trembling aspen, lodgepole pine, black spruce, balsam poplar, tamarack, subalpine fir and paper birch are major tree species found in the BWBS. Forest fires are frequent, maintaining most of the forests in various structural stages (Meidinger and Pojar,

Table 1. Biogeoclimatic zones, subzones and variants in the study area.

BGC Zone	Subzone/ Variant	Elevation (m)	Description
BWBS	dk1 – Stikine dry cool	600 to 1250 *	Climax zonal forests are comprised of White Spruce with a dominantly feathermoss understory. Seral stands containing pine and aspen are very common.
ESSF	mv4 – Graham moist very cold	1000 to 1600 *	Zonal climax vegetation is a mixed overstory of Engelmann spruce and Sub-alpine fir, frequently dominated by *Rhododendron* in the understory.
SWB	mk1 – moist cool	800 to 1600 *	Zonal climax forests consists of mixed White Spruce and Sub-alpine fir forests, with scrub birch and shrub willow present in the understory.
SWB	mks	1500 to 1900*	The parkland is transitional between high elevation forest zones and the non-forested alpine tundra zone. Characterized by lush forb-alpine grass communities, in association with shrub willow and krummholz vegetation (mostly Sub-alpine fir).
ESSF	mvp4,	1500 to 1900*	The parkland is transitional between high elevation forest zones and the non-forested alpine tundra zone. Characterized by lush forb-alpine grass communities, in association with shrub willow and krummholz vegetation (mostly Sub-alpine fir).
AT	(not applicable)	Above 1800*	AT is an upper-elevation treeless area characterized by a harsh climate and a very short growing season. Zonal vegetation is dominated by lush mixed forbs and alpine grasses at lower elevations, while at higher elevations, conditions for growth are more limiting and support a less vigorous mix of sedges, dwarf shrubs, forbs and alpine grasses.

* These are elevational ranges as determined for the Mackenzie TEM study area (i.e., as opposed to overall ranges for Subzones/Variants).

1991). True climax forests are largely unknown in the BWBS, as few stands have escaped fire for several hundred years (Delong et al., 1991).

The BWBSdk1 occupies the lower elevations of all of the major river valleys within the study area, mostly below 1100m elevation. The BWBS disappears at a somewhat lower elevation within most upper drainages, since they are typically under the influence of cold air ponding.

Generally, Alpine Tundra (AT) occurs above 1800 m. The climate in this zone is cold, windy, snowy and characterised by low growing season temperatures and a very short frost-free period. Most precipitation falls as snow. By definition, the AT is treeless. Alpine vegetation is dominated by shrubs, herbs, bryophytes, and lichens. Many areas in the AT are dominated by rock, snow and ice. Common shrubs in the study area are scrub birch and various willows (Pojar and Stewart 1991b). Figure 12 exemplifies a typical AT landscape.

The Spruce – Willow – Birch (SWB) Zone is the most northerly subalpine zone in BC (Pojar and Stewart, 1991a). The climate is characterised by long, cold winters and brief, cool summers. Winter cold spells can be broken by Chinook winds. Mean annual precipitation is 460 to 700 mm, with 35-60% occurring as snowfall (Meidinger and Pojar, 1991). Generally open, low vigour, forests are dominated by white spruce, subalpine and lodgepole pine. Aspen and Black spruce occur occasionally at lower elevations. Figure 13 illustrates a typical SWBmk1 landscape.

The Engelmann Spruce – Subalpine Fir (ESSF) Zone is the uppermost forested zone in three-quarters of the interior of BC. In the Rocky Mountains, it occurs below the Alpine Tundra zone. Growing seasons as cool and short and winters are long and cold. Most precipitation falls as snow and snow depths are deep. The Graham Moist Very Cold ESSF (ESSFmv4) occurs primarily in the Muskwa Range of the Rocky Mountains. Climax forests are dominated by Engelmann spruce and subalpine fir. However, fire occurs more frequently in this variant and a large proportion of stands are dominated by lodgepole pine. Mixtures of lodgepole pine and black spruce also occur on poor sites at lower elevations (DeLong et al., 1994). Figure 14 illustrates a typical ESSFmvp4 landscape.

The study area encompasses a transition zone from the ESSF to the colder more northern continental climate of the SWB. The southernmost extension of the SWB Biogeoclimatic zone appears in a widened level to undulating morainal/glacio-fluvial plain in the mid Akie LU. Cold air ponding is prevalent here. Traveling upstream and to the north, the SWBmk1 soon begins to replace the ESSFmv4 on north aspects as well as in valley bottoms until finally the ESSF disappears along the upper reaches of the Akie and its tributaries. On the other side of the study area, the SWB begins to appear within side valleys of the Finlay River, in the Buffalohead LU. Because of the transitional nature of the area, recognition of SWB/ESSF boundary can be problematic. For example, many ESSFmv4 sites within the study area support very sparse and sporadic Rhododendron cover, perhaps as a result of the soil's high lime content.

This area of the ESSFmv4 and the SWBmk1 appear to have significantly more precipitation – particularly high winter snow packs – than the same climatic subzones on the (eastern) lee side of the Rocky Mountains. The drying effect of the Chinook winds may also be significant on the east slopes. The seral pine and aspen forests are much more rare in mid to upper Akie-Pesika River Valleys than in the Sikanni Chief and other drainages flowing out of the east slopes. On west slopes, the lack of edaphic grasslands and high populations of large grazing ungulates is notable and evident.

1.7 Wildlife

The Study Area contains a diverse array of habitats that support a range of vertebrate wildlife. High elevation alpine and parkland meadows, grasslands and shrublands provide high quality summer ranges for mountain goat, caribou, Stone sheep, elk and grizzly bear (Figure 2). Low elevation forests, wetlands and grasslands (Figure 3) provide important winter ranges for moose and caribou and some elk and mule deer and year-round habitat for

Figure 2. High elevations in the Akie-Pesika provide summer habitat for a wide range of wildlife, including Stone sheep, mountain goat, caribou and grizzly bear.

furbearers, such as marten, fisher and lynx. The construction of the W.A.C. Bennett dam and the subsequent flooding of the Rocky Mountain Trench, now occupied by Williston Reservoir, has drastically changed the wildlife values in this portion of BC. Nevertheless, high quality low elevation winter ungulate habitat still exists. Outside of the Rocky Mountain Trench, deep snow and harsh winter conditions limit use by many ungulates, especially elk and mule deer.

In the following sections, wildlife habitat characteristics of each of the six BGC subzones/variants in the Study Area are described.

Figure 3. Low elevation forests, wetlands and grasslands provide important ungulate winter range and year-round habitat for a variety of species, including furbearers.

BWBSdk1

This zone provides especially important winter range for caribou and moose. A population of elk is also present along grassy south-slopes near the Ingenika River. In 1993, the existing elk herd population was supplement with 50 transplanted elk (Wood, 1993). Snowshoe hare, lynx, deer mice, ermine, black and grizzly bears and red squirrels are commonly found throughout the zone. South-facing slopes provide warm, lower snow depth habitats for all of the ungulate species and thus for many predators like wolves and wolverine. Stone sheep and mountain goat may also found in the BWBS where steep slopes provide escape terrain and where mineral licks are located.

In lowland areas, the BWBS contains numerous bogs, fens and riparian areas. These productive habitats play important roles for a variety of wildlife, including moose who come to the lowlands for winter browse. The large number of snags associate with wet areas provide habitat for cavity-nesting/denning birds and small mammals such as three-toed woodpecker, red-breasted nuthatch, black-capped chickadee, boreal owl, boreal chickadee, red squirrel, American marten, fisher and lynx (DeLong et al., 1991).

ESSFmv4

Deep snowfalls in the ESSF make winter conditions for many species very difficult although mountain goat and caribou are well adapted and present throughout. In summer, the ESSF is widely used by grizzly bear, elk, mule deer and moose. Avalanche tracks (Figure 4) are widespread in the ESSF and provide abundant forage for ungulates and bears. Extensive conifer forests provide habitat for marten, fisher, red squirrel, wolverine and lynx as well as for a variety of seed-eating birds, such as red and white-winged crossbills, Clark's nutcrackers and pine siskins (Coupé *et al.*, 1991). Wetlands and riparian areas are typically not as productive as those at lower elevations.

Figure 4. An avalanche track in the ESSF zone. These areas provide high quality food for ungulates and bears.

SWBmk1

The SWB zone has the harshest climate of all the forested subzones in British Columbia and this has a profound effect on wildlife. The zone is composed of a mosaic of mostly open-canopied coniferous and mixed forests, willow-birch shrublands, grasslands, rugged, steep slopes and some wetlands, riparian areas and floodplains (Pojar and Stewart, 1991a). High elevation grassy southern aspects in the SWB are utilised by Stone sheep and mountain goats year-round and by grizzly bear, deer, elk and caribou in the growing season. In winter, they are windswept and heated by the sun reducing snow levels and exposing food during this critical time of year. Steep, rocky upper slopes are important escape terrain for both Stone sheep and mountain goats and golden eagles and gyrfalcons use this type of habitat for hunting.

Wetlands (Figure 5), riparian habitats and floodplains are not as abundant or as productive as in the BWBS but are used extensively by moose, bears, voles, ducks, songbirds, beaver, muskrat, various raptors like the eagles, northern harriers, and large mammals like bison. Cold-air drainage and ponding create open, shrubby valley bottoms in many areas of the SWB. These habitats provide abundant browse year round although many areas are limited by snow depth in winter (Pojar and Stewart, 1991a).

Figure 5. Sedge-Asphodel fen in the SWBmk1.

Coniferous and mixed forests provide habitat for species such as northern Goshawk, northern hawk-owl, spruce grouse and three-toed woodpecker use this forest type extensively for foraging and nesting. Forested areas in the SWB also provide security and thermal protection in winter.

ESSFmvp4 and SWBmks1

At high elevations, the ESSF and SWB have parkland variants (for the SWB, scrub is often used in place of parkland) that occupy the intergrading area between forest and alpine tundra. These variants are sparsely forested and much of the zones are characterised by herb, shrub and dwarf-shrub communities and by rugged, steep slopes. Windblown portions of these areas have low snow depths providing habitat for wintering caribou and Stone sheep. These areas are especially important when snow depths are high at low elevations. In summer, a number of birds, ungulates and bears feed inn lush meadows and grasslands of the parkland zone.

AT

The harsh climate, rugged topography and low plant productivity in the AT result in low wildlife diversity and density. However, some wildlife species, such as mountain goat, pika, hoary marmot, willow and white-tailed ptarmigan, water pipits, caribou, Stone sheep and rosy finch are well-adapted to the conditions found here (Pojar and Stewart, 1991b). Grassland and scrub areas may be used extensively by ungulates during the summer months. In winter, these areas are utilised by goats, caribou and Stone sheep, which feed off lichens and dwarf shrubs, only where wind and solar radiation have reduced the snow depth. Grizzly bears use alpine meadows for food in the growing season. Other wildlife found seasonally in the AT include: snowshoe hare, voles, mule deer, black bear, wolverine, golden eagle, white-tailed ptarmigan, horned lark, golden eagle, golden-crowned sparrow and gyrfalcon (Pojar and Stewart, 1991b).

1.7.1 Previous Studies

Aerial wildlife surveys have been conducted on a periodic basis since the 1960s and include:

- Resource Analysis Branch (1969),
- Resource Analysis Branch (1974),
- Resource Analysis Branch (1974),
- Wildlife Branch (1990),
- Wildlife Branch (1990),
- Wildlife Branch (1991),
- Watts and Child (1986),
- Hatler (1990), and
- Wood (1994).

Wildlife habitat mapping has also been conducted, although at very large scales. Habitat Inventory Section (1994) produced wildlife capability maps for northeastern British Columbia at 1:250,000 scale.

2.0 WILDLIFE HABITAT INTERPRETATIONS METHODOLOGY

A framework for wildlife habitat mapping has been established by the Wildlife Interpretations Subcommittee (RIC, 1998a) and our methods conform to these standards. In this section, we describe our specific approach used to produce the wildlife habitat suitability maps. Figure 6 shows the stages within distinct phases in the developmental process. Each of these phases are described below.

2.1 Species Accounts and Preliminary Ratings

The first stage in the process involved defining each species' requirements for survival and the relationship between these requirements and habitat features and attributes present in the study area. This forms the basis for the species-habitat model.

We collected background wildlife information for both the study area and adjacent areas from the following sources:

- B.C. Conservation Data Centre (CDC);
- Primary literature from UBC and SFU libraries;
- Prince George MELP staff;
- Wildlife Branch (MELP, Victoria);
- Peace/Williston Fish and Wildlife Compensation Program

In order to rate the suitability of a habitat for a given species, the life requisites of the species must be explicitly defined. Life requisites are the requirements of an animal for sustaining and perpetuating the species. These requirements are provided by the species' habitat and most commonly include food, security and thermal protection. Other life requisites may include denning, migrating and living. In our models, living encompasses all of a species life requisites and directly reflects where animals are likely to be found, assuming they are present in the Study Area.

Following the development of the species accounts, preliminary ratings were assigned to broad habitat categories present in the study area. This provided an indication of those areas that provide significant wildlife habitat and serves to direct the locations of the field sampling.

2.2 Field Data Collection

The field data collection is divided into two periods: winter and summer. The winter data collection consisted of a reconnaissance level aerial survey to determine winter wildlife distribution and habitat use. During the summer field session, we completed wildlife habitat

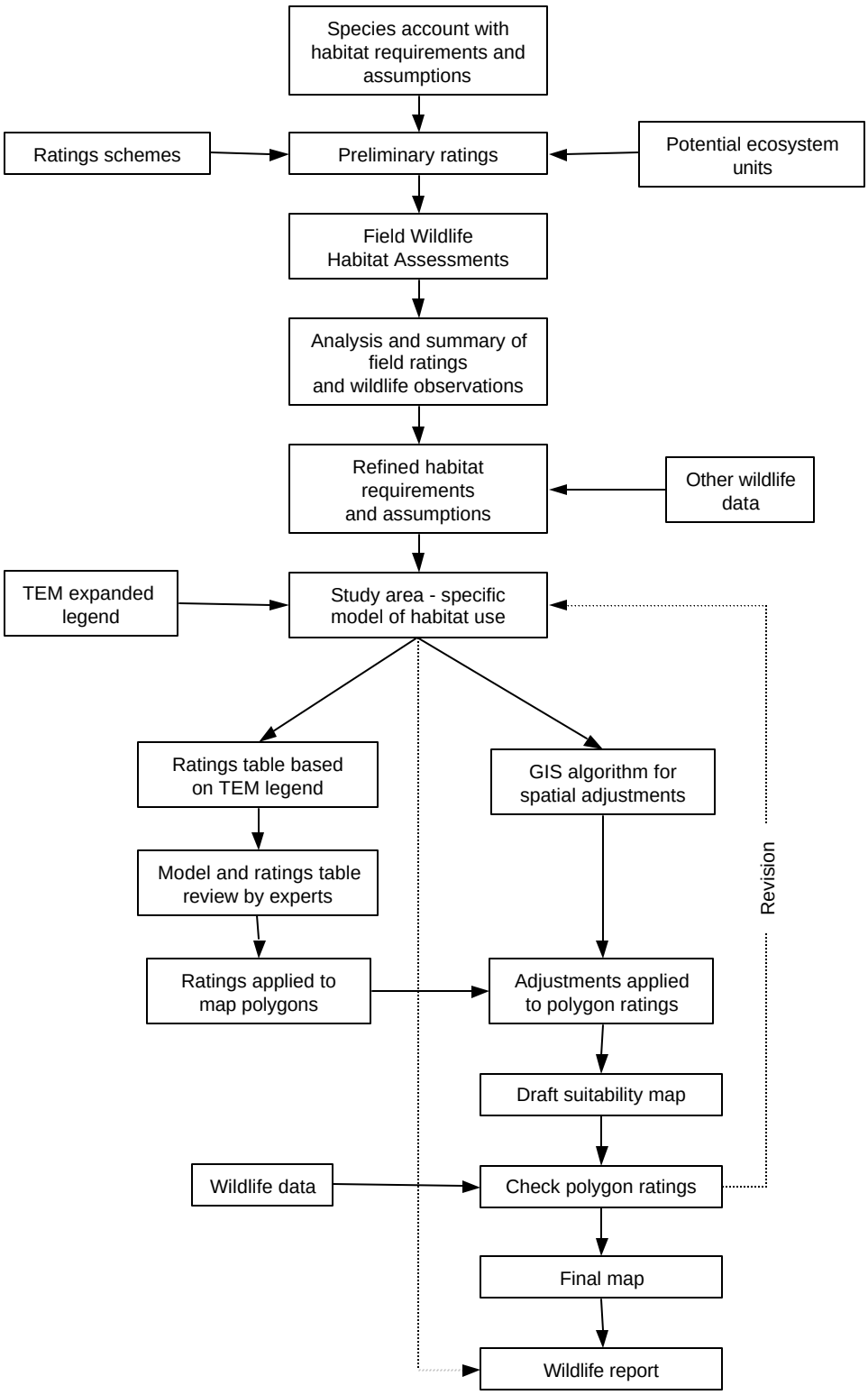

Figure 6. Developmental process for the wildlife habitat interpretations.

assessments in association with TEM full plots and ground inspections, recorded evidence of animal use, and recorded all incidental encounters with wildlife.

2.2.1 Winter

On March 5, 1997, a reconnaissance aerial survey was conducted using a Bell 206 Jet Ranger. The purpose of the survey was to determine general trends of winter wildlife distribution and habitat use.

All animals encountered were recorded and classified. The survey had three observers plus the pilot. A survey transcript is contained in Appendix B.

2.2.2 Summer

Summer sampling was conducted from July 3rd to Sept 12th 1997 and July 29th to Aug 4th 1998 by member companies of the KTPW-Geo Consortium. We used 3-person crews consisting of a soil scientist, a plant ecologist and a wildlife biologist to complete full plots, ground inspection plots, vistas and wildlife habitat assessments.

The purpose of the Wildlife Habitat Assessments (WHAs) was twofold: (1) to establish the relationship between a species' life requisites and the attributes of each ecosystem unit; and (2) to document signs of animal use.

A six-class habitat rating scheme was used to rate a habitat's potential to support a species for a given season and use relative to the best habitat in the province (Table 2). Ratings were assigned using a set of rating criteria developed from the species accounts and the preliminary ratings. The seasons and uses are listed in Table 3.

Table 2. The 6-class habitat rating scheme used to rate a habitat's potential to support a species for a given season and use relative to the best habitat in the province.

Code	Rating	Percent of Provincial Best
1	High	Equivalent (75-100% of best)
2	Moderately high	Slightly less (50-75% of best)
3	Moderate	Moderately less (25-50% of best)
4	Low	Substantially less (5-25% of best)
5	Very low	Much less (0-5% of best)
6	Nil	The habitat or attribute is absent

Sampling Design

The Wildlife Habitat Assessments generally followed the sampling strategy of the Ecosystem Field Plots (because the WHAs must be associated with either a Full Plot or a Ground Inspection Plot). To ensure that there was adequate representation of habitats for all of the eleven featured species, the selection of Ecosystem Field Plots was conducted in direct consultation with the wildlife habitat specialists.

WHAs were completed for each of 378 Full Plots (Table 3). As a subsample of the Ground Inspection Plots, 168 WHAs were completed. The subsampling of WHAs were installed with Ground Inspection plots that represented a range of ecosystem conditions and in areas of suitable habitat. By only doing a portion of the Ground Inspection plots, the wildlife biologists were provided with sufficient time to complete the full WHA form and time to search the plots and adjacent habitat for signs of use by the eleven species. This number of WHAs was determined to be sufficient to develop a clear understanding of the relationship between the needs or life requisites of each species and the habitats available within the Study Areas.

Table 3. Wildlife habitat assessments completed in the Mackenzie TEM Study Area listed according to the year and type of ecosystem plot it was completed with.

Plot Type	1997	1998	Total
Full plot	357	21	378
Visual (ground inspection)	146	22	168
Total	503	43	546

Conduct of the Wildlife Habitat Assessments

Each WHA card was linked to a accompanying Full Plot or Ground Inspection Plot by recording the project and plot number. When a site was visited in the field where a Full Plot or a Ground Inspection Plot was to be completed, the wildlife biologist within the crew recorded the BEC sub-zone, Site Series and structural stage on the WHA form. The wildlife biologist then walked the plot and visited adjacent habitats before assigning a rating for a particular use for each species. Signs of use by any of the eleven species were also recorded. Field notes were also taken to further describe the site or to record signs of use by non-target species.

At the end of each field day, the sampled plots were marked on a matrix of all site series and structural stages. This technique was used to monitor the distribution of samples across all combinations of available habitats within the Study Area.

A large number of incidental wildlife records were collected during the field session. Both target and non-target species were recorded as they were encountered. Locations of mineral licks and animal congregation areas were also recorded. These lists, combined with the plot data and other spatial wildlife data, will provide an important reference database during the construction of the wildlife models and will be used during the map verification phase of the project.

Compilation and Analysis of Field Ratings

Once the field surveys were completed, WHA and observational data were used to develop unique habitat-use algorithms that were applied to the TEM mapping. Field form data were transcribed to computer spreadsheet data files, and sorted/analyzed. These were then used in the development and refinement of the species model for each species being examined in the study.

2.3 Species-Habitat Models

The purpose of the species model is to document how the mapped ecosystems in the Study Area satisfy a species' requirements for survival. These requirements, referred to as life requisites, include a species' basic requirements for food, security and, for some, thermal protection, reproduction, denning and living. Living is a function of the spatial arrangement of food, security and thermal protection in the landscape and depicts where animals are likely to be found, assuming they are present in the area.

The procedure for the development of a species-habitat model involved the following steps:

1. The relationship between the mappable ecosystem attributes and the species' life requisites were explicitly defined (these are the assumptions);
2. A formal ratings table which assigns suitability ratings for each life requisite (food, security and thermal protection) to each ecosystem unit based on the assumptions was developed;
3. The adjustments needed to modify the ecosystem unit ratings to account for habitat requirements that are not inherent properties of the ecosystem unit (e.g. aspect, canopy closure or slope) were determined; and,
4. Rules for how the life requisites combine to produce suitable habitat for living, reproduction, denning, etc. were determined;

2.4 Rating Schemes and Map Themes

Polygon ratings for each season and life requisite are contained in the digital map database for each species. However, it is not possible to depict all of this information on printed maps. Table 4 summarizes the rating scheme and the map theme for each species.

Table 4. Rating schemes and map themes for each of the eleven species.

Species	Rating Scheme [a]	Map Theme [a]	Spatially Adjusted?
American marten	FD-W, SH-W, LI-W	LI-W	No
Fisher	FD-A, SH-A, LI-A	LI-A	No
Lynx	FD-A, SH-A, LI-A	LI-A	Yes
Wolverine	FD-A	FD-A	No
Grizzly bear	FD-P, FD-S [b], SH-G, LI-P, LI-S	LI-S [b]	Yes
Moose	FD-G, ST-G, FD-W, ST-W, LI-G, LI-W, LI-A	LI-W	Yes
Elk	FD-G, ST-G, FD-W, ST-W, LI-G, LI-W, LI-A	LI-W	Yes
Caribou	FD-WE, FD-WL, FD-P, FD-S	FD-WE	No
Mountain goat	FD-G, FD-W, SH-A, LI-G, LI-W	LI-W	Yes
Stone sheep	FD-G, FD-W, SH-A, LI-G, LI-W	LI-W	No
Northern Goshawk	FD-G, SH-G, RP-G	FD-G	No

[a] Seasons: P- spring; S- summer; F- fall; G- growing; W- winter; WE- early-winter; WL- late-winter.; A- all seasons. Uses: FD- food; SH- security; ST- security/thermal; LI- living.
[b] For grizzly bear, "S" includes both summer and fall.

2.5 Generation of the Ratings Tables

Based on the models, a ratings table contains suitability ratings for each ecosystem unit (a combination of Ecosection, BEC unit, site series, site modifiers, structural stage and stand composition). The ratings table serves two purposes. It provides:

- An individual rating for each ecosystem unit that reviewers can critique, if they have visited or are familiar with the units; and,
- A look-up table that provides base ratings that are assigned to map polygons.

We generated the ratings using an additive model:

Rating = 1+[Ecosection]+[BEC Zone/Subzone/Variant]+[Site Series]+[Structural Stage] +[Stand Composition],

where each term in the model represent the influence of that attribute on habitat suitability. Each possible value for an attribute was given a degrading score relative the optimal value for the attribute. For example:

> *The optimal structural stages for American marten are mature and old forest. These stages have a degrading score of zero. A sub-optimal stage, such as pole/sapling, has a degrading score of minus three.*

The degrading scores for Ecosection, BEC Zone/Subzone/Variant, site series, structural stage and stand composition are all scored in a similar manner. By summing all of the degrading

scores for a single ecosystem unit, a base habitat suitability can be calculated. The degrading scores are listed in the model for each species.

To generate ratings for all ecosystem units, we used a relational database in Microsoft Access. Figure 2 shows a sample screen capture of a database model for one of the species.

This automated approach to generating the ratings tables has several advantages:

1. Ratings for a large number of ecosystem units can be generated quickly and efficiently;
2. Revisions to the ratings table are fast (for example, if an assumption about structural stage use changes, a new ratings table can be generated instantaneously for all occurrences of that structural stage);
3. Inconsistencies due to subjective evaluation are reduced; and,
4. Data entry errors are minimised.

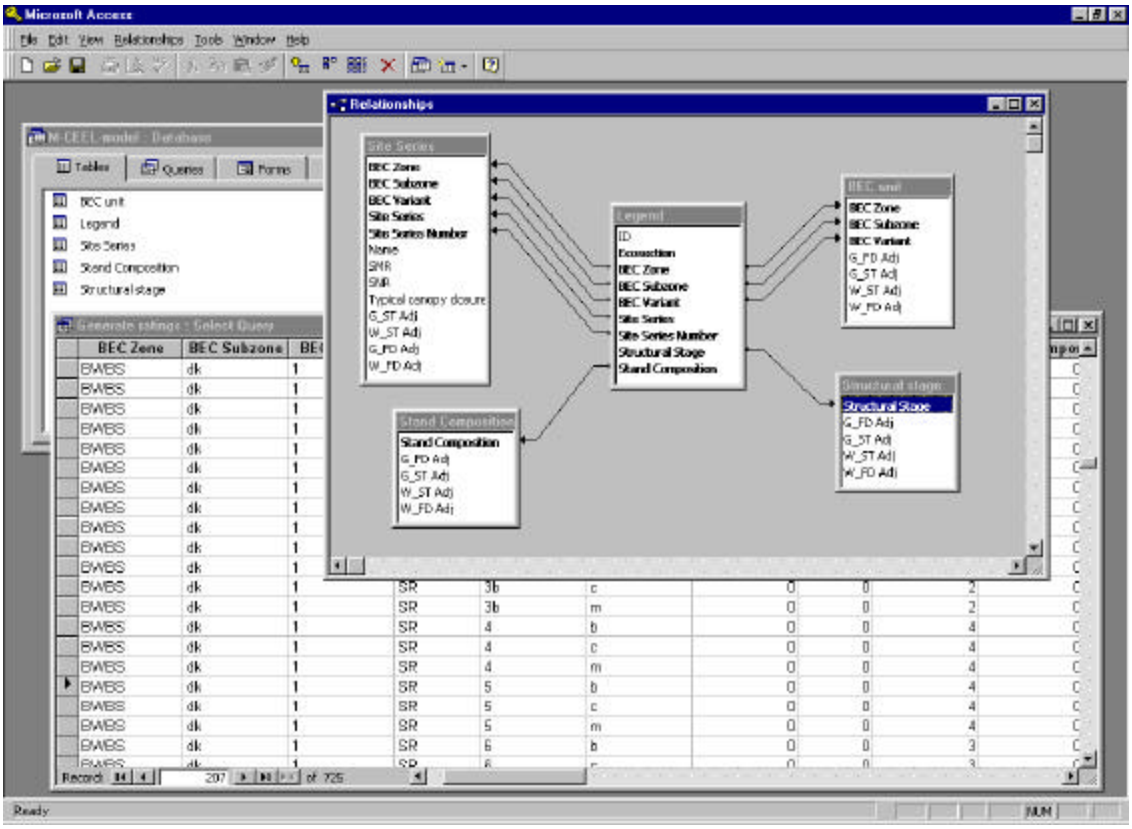

Figure 7. A screen capture of the relational database (in Microsoft Access) used to generate the ratings tables.

Given the map scale, the size of the Study Area and the knowledge of species-specific habitat use in the Study Area, we have used a relatively simple model. However, complex models could potentially be used to generate ratings for a large number of ecosystem units in a cost-efficient manner.

2.6 Polygon Ratings

The generation of the polygon suitability ratings involved several steps.

A. Ratings were assigned to each decile (ecosystem unit in a complex polygon) from the ratings table for each season and use (e.g., food and security for growing and winter) for each species.

B. Polygon-specific adjustments were applied to each decile rating. For example, a thermal rating in winter would be decreased if the decile contained a cool aspect. Other common adjustments included adjustments for steep slopes and various terrain types that afford security for some species (e.g. undulating terrain).

C. The polygon rating for each season and use was selected as the best rating of any decile.

D. A GIS algorithm was used to generate habitat suitability ratings for living. The living rating reflects the expected use of a polygon if the species is present in the area. Since many of the target species have spatially separated life requisites (e.g. food and security are provided by different types of ecosystems), the availability of habitat in adjacent polygons is important.

   For example, a polygon that provides food and no security would be rated low for living because of the lack of security. However, if security is provided in an adjacent polygon (within reasonable proximity, depending on the ecology of the species), both food and security are provided and the target polygon is thus rated higher for living.

The first three steps were performed using Microsoft Access. This methodology is explained more in Appendix D. The remaining step was done in Arc/Info Version 7.1.

2.7 Model and Map Verification

Once models were complete, a review/verification process was followed:

- Review of the written model by species experts;
- Correlation with the provincial standards;
- Comparison of draft maps with wildlife distribution data; and,
- Model revision.

The revision process involved several iterations. This review process ensures that the assumptions are well supported and there is a high level of consistency among those who are developing wildlife habitat models in various parts of the province for the same or similar species.

3.0 SPECIES-HABITAT MODELS

The species-habitat model serves several purposes:

- Describes the species' requirements for survival;
- Describes the relationship between the species' life requisites and spatial habitat attributes; and
- Defines a numerical relationship between a species' habitat requirement and the TEM database and other supplementary spatial data.

A ratings table is generated using the assumptions described in the model. The ratings table contains suitability ratings for food, security and thermal protection for each ecosystem unit that has been mapped in the study area. These ratings are then applied to the map database using a GIS algorithm. The ratings tables are contained in Appendix F.

Each species-habitat model follows a consistent, defined structure with the following sub-sections:

DISTRIBUTION, lists the provincial range, study are distribution and the provincial benchmark for the species;

ECOLOGY AND HABITAT REQUIREMENTS, describes the species requirements for survival;

LIFE REQUISITES/SEASONAL USE PATTERNS, describes the species' specific life requisites;

HABITAT USE AND ECOSYSTEM ATTRIBUTES, relates the life requisites to mappable ecosystem attributes, such as Ecosection, biogeoclimatic zone, site series, structural stage, stand composition, and proximity and spatial requirements;

HABITAT RATINGS, describes the rating scheme, modeling theme**,** and the numerical relationship between the habitat assumptions and the ecosystem attributes; and

REFERENCES.

3.1 American Marten (*Martes americana*)

SPECIES NAME: American marten
SCIENTIFIC NAME: *Martes americana*
SPECIES CODE: M-MAAM
STATUS: Not at risk (MELP, 1997; COSEWIC, 1997)

DISTRIBUTION

Provincial Range

American Marten are found throughout mainland British Columbia, on Vancouver Island and on the Queen Charlotte Islands in addition to several smaller coastal islands (Nagorsen, 1990).

Provincial Benchmark

Ecoprovince: Not established
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR), Missinchinka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, SWBmks1, ESSFmv4, ESSFmvp4, and AT
Elevational range: Valley bottom to subalpine

ECOLOGY AND HABITAT REQUIREMENTS

Marten are generally associated with late-successional stands of mesic conifers, especially those with complex physical structure near the ground (Buskirk and Ruggiero, 1994, reviewed by Becker, 1992). They may use younger forests and even open areas in the snow free seasons if good cover is provided nearby. The complex physical structure near the ground provides escape space/refuge sites; access to subnivean space where most prey are captured in winter; and protective thermal environments, especially in winter (Buskirk and Ruggiero, 1994). They require well insulated resting dens when not active. Dens are almost always subnivean and typically associated with coarse woody debris such as squirrel middens, stumps, snags, and the root masses of large trees (Lofroth and Steventon, 1990).

Marten diet varies by season. In summer, their diet includes bird's eggs and nestlings, insects, fish, fruit and young mammals. In winter, voles, mice, hares and squirrels dominate (Buskirk

and Ruggiero, 1994). Marten hunt mostly on the ground, though they are good climbers and may chase squirrels or reach bird nests by climbing. Hunting is often done beneath the snow and fallen logs or rocks are used to access the subnivean spaces (Stevens and Lofts, 1988). Food is a significant factor limiting marten presence and distribution, especially in winter. Fluctuations in small mammal densities in Montana were believed to directly affect the carrying capacity for marten (Weckwerth and Hawley, 1962). However, large quantities of snow in winter with limited access routes to get at prey below deep snow may be more restrictive on marten winter densities than the actual density of prey present (Clark and Campbell, 1976). Thompson and Harested (1994) suggest that although marten have been reported to show some diet preferences, it is unlikely that the presence of individual prey species influences habitat selection.

Resting sites are very important to marten and include fallen trees, dense vegetation, natural cavities between rocks or stumps and in trees. The resting sites provide thermal shelter during inclement weather to reduce energy expenditure. Resting sites are often located near recent kills (Stevens and Lofts, 1988). In Wyoming, Clark and Campbell (1976) report that marten frequently select large (35 to 152.2 cm dbh), rotten Engelman spruce or sub-alpine fir snags as refuge sites.

Marten prefer coniferous stands with a closed canopy. Recorded canopy closure preferences vary widely; from as low as 20% to as high as 100%. Koehler and Hornocker (1977) report that habitat with less than 30% cover is utilised but movement about these areas may be restricted to edges. In Colorado, marten have been recorded searching for prey 0.8 to 3.2 km from forest cover from May to November (Streeter and Braun, 1968). In these cases, they were most commonly found in boulder fields looking for prey such as pikas (*Ochotona princeps*). Lefroth (1994) suggests that differences in canopy closure preferences must be interpreted in the context of the range of canopy closures that are available in the area.

There is little documentation on the requirements of natal den sites however logs, trees, rocks and snags account for the greatest number of reported dens (Buskirk and Ruggiero, 1994). The availability of natal sites may be related to structural complexity, often associated with old-growth forests.

Males generally have larger territories than females. A male's territory ranges from 0.9 km^2 to 17.9 km^2 and may overlap those of several females. The female home range may be from 0.5 km^2 to 8.5 km^2 (Stordeur, 1985). Home range size depends upon prey and habitat.

Marten home range does not shift among seasons although they do specialise in the higher quality portion of their range during winter (Buskirk and Ruggiero, 1994). Winter is considered the most critical season for marten when habitat requirements are most restrictive (Allen, 1982; Buskirk and Ruggiero, 1994; Lefroth and Steventon, 1990).

Little is known about landscape-scale marten habitat use. Attributes such as stand size, stand shape, area of interior, amount of edge, use of corridors and connectivity may be important in marten habitat selection but are almost completely unknown (Buskirk, 1992). Reports of minimum habitat size have been estimated in the western US to be approximately 2.59 km^2 for

males. Based on this information, it is assumed that at least 2.59 km² (approx. 256 ha) of suitable habitat must be available before an area will be occupied by this species (Allen, 1982).

Marten are adversely affected by logging and by forest fires, both of which may remove overhead cover and coarse woody debris (Buskirk and Ruggiero, 1994; Strickland and Douglas, 1987; Thompson and Harestad, 1994).

LIFE REQUISITES/SEASONAL USE PATTERNS

Marten habitat requirements are divided into security, food, denning and living (Table 5).

Table 5. Marten seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Security	Winter	October to May
2.	Food	Winter	October to May
3.	Security	Growing	June to September
4.	Food	Winter	June to September
5.	Denning	Winter	March-April
6.	Living	Growing, Winter	June to September, October to May

Security

Security habitat (which provides cover) is required in all seasons, however, winter cover is considered the single most important factor determining habitat selection for marten (Allen, 1982; Buskirk and Ruggiero, 1994). If adequate winter cover is available, habitat requirements during other seasons may also be satisfied. For example, an area that provides suitable winter cover will also provide suitable summer cover, and suitable habitat for feeding, denning etc.. Habitat characteristics that relate to the provision of cover are therefore emphasized. Good security habitat is characterised by a coniferous canopy with canopy closure greater than 30% and high coarse woody debris.

Food

In winter, food availability is closely linked to security—those areas that provide good security provide access to subnivean spaces where prey are captured. Thus, habitat that provides security provides adequate feeding. During the growing season, marten may also use areas for feeding that are not suitable for winter cover.

Denning

Dens have been found in logs, trees, rocks and snags. We assume that natal den sites is provided in habitat with good security.

Living

Habitat that provides living contains both security and food. These requisites are often provided in the same habitat, however, marten will feed in areas with sub-optimal security if there is adequate security nearby in summer. In winter, marten habitat can only be as good as the security it provides.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between marten habitat use and TEM ecosystem and terrain attributes are described in Table 6.

Table 6. Marten habitat use as it relates to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Marten occur in the WMR, EMR, MIR and CAR Ecosections. On a provincial scale, it is estimated that the study area provides up to 50% of the best habitat in the province, corresponding to a suitability rating of 3 (moderate). However, some ecosystems in the study area do provide optimal marten security and/or food habitat, although these areas are either not large or are poorly connected, thus providing poor living habitat.
Biogeoclimatic Zone	Marten potentially occur in all of the BGC zones and sub-zones in the study area, however, they are unlikely to occur in the AT in winter. The ESSFmv4 has the greatest potential to provide the high quality marten habitat. Zones where lodgepole pine are predominantly present (primarily the BWBSdk1) generally provide lower quality habitat.
Site Series	In general, moister site series (soil moisture regimes from sub-mesic to sub-hygric) provide better marten habitat than drier site series (very xeric to sub-xeric) in each of the BGC sub-zones. Moister sites typically have higher canopy closure and denser shrub and herb layers (MOF, 1996), providing better cover and prey habitat. However, very wet sites (those with seepage water) (hygric to sub-hydric) typically have a lower canopy closure (MOF, 1996), and are rated lower than moist sites. Mesic and moist sites are also likely to have higher coarse woody debris than both very wet and very dry sites. Lofroth (1994) found that marten avoided xeric habitat types and wetlands in a study in the Sub-Boreal Spruce Zone. Similarly, site series with poor and very poor soil nutrient regimes (SNR) provide lower quality food and security habitat than sites with medium to very-rich SNRs.
Structural Stage	The habitat characteristics considered important for marten are often associated with the structural features present in advanced successional forests, such as overhead cover, especially near the ground; high volumes of coarse woody debris, especially of large diameter; and small-scale horizontal heterogeneity of vegetation (Allen, 1982; Buskirk and Ruggiero, 1994). Allen (1982) considers that early successional forests provide no marten habitat, mid-successional forests provide moderate marten habitat and mature or old growth forests provide optimum value. Lofroth (1994) found marten in the Sub-Boreal Spruce zone avoided young seral stages. Younger structural stages generally cannot provide winter habitat because there is insufficient CWD to provide access to the sub-nivean spaces. Structural stages from young forest (05) to old growth (07) potentially provide habitat for year-round living. It is assumed that non-vegetated and herbaceous structural stages (01 and 02) do not represent marten habitat.
Canopy Closure	Sites with high canopy closure provide optimal security. The effect of canopy

TEM Attribute	Habitat Use
	closure has been incorporated into the site series assumptions described above.
Coarse Woody Debris	Coarse woody debris (CWD) is an important habitat attribute for marten, however, prediction of map units with high CWD is difficult. Late successional forests are most likely to contain the highest CWD (discussed above). As well, productive, mesic site series are likely to have higher CWD than both drier and wetter site series.
Stand Composition	Coniferous tree canopies provide optimal security for marten. Broadleaf and mixed canopies have low winter crown closure and thus provide poorer security.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 6-class rating scheme is used to depict marten food (FD), security (SH) and living (LI) habitat in winter. The model depicts marten habitat in winter, when habitat is most limited. However, habitat used in winter is also used in summer and marten will be found in these areas year-round. In the growing season, marten additionally feed in habitats with lower canopy closure and less coarse woody debris that are otherwise not suitable in winter.

Food (FD) and Security (SH) Habitat Assumptions

The ratings table assigns a suitability rating for FD and SH to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. A degrading score relative to the optimal value for the attribute (Table 6) defines the relationship between marten life requisites and the ecosystem attributes. For example, the optimal structural stage for marten security (old forest) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 3, which would result in a max rating of 4 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Polygon Food (FD) and Security (SH) Adjustments

There are no adjustments to the polygon food and security ratings.

Living (LI) Habitat Assumptions and Adjustments

The LI rating is a combination of the FD and SH ratings. Since a given habitat can generally only be as good as the most limiting life requisite, LI is calculated as the lower rating between the polygon FD and SH rating. For complex polygons, the best rating of any decile is used for each life requisite.

Table 7. Marten food and security habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score	
			SH-W	FD-W
1. BGC Unit	**CAR**	BWBSdk1	2	2
		ESSFmv4	2	2
		SWBmk1	3	3
		ESSFmvp4	4	3
		SWBmks1	4	4
		AT	5	5
	MIR	ESSFmv4	2	3
		ESSFmvp4	4	3
		AT	5	5
	EMR	SWBmk	3	3
		SWBmks	4	4
		AT	5	5
	WMR	BWBSdk1	2	2
		ESSFmv4	2	2
		SWBmk1	3	3
		ESSFmvp4	4	3
		SWBmks1	4	4
		AT	5	5
2a. Site Series (SMR)		Xeric	2	2
		Subxeric	1	1
		Submesic	0	0
		Mesic	0	0
		Subhygric	0	0
		Hygric	1	1
		Subhydric	2	2
		Hydric	2	2
2b. Site Series (SNR)		Very poor-poor	1	1
		Medium-very rich	0	0
3. Structural Stage		Sparse (1a)	3	3
		Bryoid (1b)	3	3
		Herb (2)	3	3
		Low shrub (3a)	3	2
		Tall shrub (3b)	3	2
		Pole/sapling (4)	1	1
		Young forest (5)	1	1
		Mature forest (6)	0	0
		Old forest (7)	0	0
4. Stand Composition		Broadleaf (b)	2	1
		Mixed (m)	1	1

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3.2 Fisher (*Martes pennanti*)

SPECIES NAME: Fisher
SCIENTIFIC NAME: *Martes pennanti*
SPECIES CODE: M-MAPE
STATUS: Blue-listed (MELP, 1997); not at risk (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

Fisher are found throughout mainland British Columbia although they are rare in coastal ecosystems (Nagorsen, 1990; MOF and BCE, 1997)

Provincial Benchmark

Ecoprovince: Not established
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, SWBmks1, ESSFmv4, ESSFmvp4, and AT
Elevational range: Valley bottom to subalpine

ECOLOGY AND HABITAT REQUIREMENTS

Fishers are distributed throughout the forested areas of North America and most of British Columbia. Optimal habitats are considered mature coniferous forests and mixed conifer/hardwood stands, mostly in areas of continuous overhead cover (Allen, 1983; Powell, 1992). Fishers may forage in different habitats from the ones they use for resting and denning therefore, a complete description of fisher habitat requirements must consider both foraging and resting and denning needs.

Throughout their range, fishers exhibit a strong preference for forests with high canopy closure and avoid areas with low overhead cover. In the Pacific States and the Rocky Mountains, fisher appear to prefer late-successional coniferous forests (Krohn *et al.*, 1996) and use riparian areas disproportionately more than their occurrence (Powell and Zielinski, 1994). Forest structure is

likely more important to fisher than specific forest types. Vertical and horizontal complexity, created by a diversity of tree sizes and shapes, light gaps, dead and downed wood and layers of overhead cover, provide good prey habitat, dens and resting sites (Powell and Zielinski, 1994). Fishers infrequently use large forest openings, open hardwood forests, recent clear-cuts, grasslands, areas above timberline and other non-forested areas (Powell and Zielinski, 1994). In fact, Powell (1992) states that fisher have avoided open areas 25m across or less in the Midwest.

Fishers are opportunistic feeders (Banci, 1989) and their prey may occur in a variety of forest types and seral stages (Powell and Zielinski, 1994). Rabbits and rodents form the bulk of their diet but they will eat virtually any vertebrate that they are capable of killing (Forsyth, 1985). Other common prey items include birds, fish, snakes, toads, insects, fruit, seeds, berries, fern tips and carrion (Forsyth, 1985). Habitats with high small mammal diversity, such as riparian areas, wetlands and mixed conifer-hardwood forest types, are most preferred (Kelly 1977 as cited in Powell, 1992).

Resting and denning sites tend to occur in structures associated with late-successional forests (Powell and Zielinski, 1994; Jones and Garton, 1994). This includes large trees, snags and logs greater than 55 cm dbh on average (Powell and Zielinski, 1994). Natal dens are located most often in cavities of large, dead trees situated 7 to 12 m above the ground (Banci, 1989). In most studies done in eastern North America, den sites were in hardwoods and over half were in aspens (*Populus* spp.). According to Powell and Zielinski (1994), only two natal dens and one maternal den have been recorded in western North America and these three dens were not in hardwoods.

Some authors have shown differences in fisher winter and summer habitat. Jones and Garton (1994), studying in the Rocky Mountains of north-central Idaho, found that fishers preferred mature and old-growth forests during summer but additionally selected young forests in winter. They hypothesized that the shift to younger stages may be due to a shift in prey use, specializing more towards snowshoe hare. Kelly (1977, as cited in Powell, 1992) also found changes in seasonal habitat use. Regenerating clear-cuts were avoided during winter but used during the summer (presumably for feeding) and concluded that fisher perceive the dense cover from saplings as adequate overhead cover. Banci (1989) reports that seasonal elevational changes in fisher habitat use does not occur.

Fisher have been found to be confined to or have greater density in areas with low snow accumulation (Powell, 1992). Travel in deep snow is energetically costly and, compared to marten, they are less able to access the sub-nivean spaces because of their large body size. Where snow is deep and frequent, fishers should be expected to be either absent or occur where dense overhead cover intercepts snowfall (Krohn *et al.*, 1996).

Riparian forests appear to be very important for fisher, especially in the west (Jones and Garton, 1994; Powell, 1992; MOF and BCE, 1997). These areas likely provide several functions including high prey abundance, abundant snags for dens/resting sites and high canopy closure which provides snow interception.

Fishers can travel long distances during short periods of time, about 5-6 km per day (reviewed by Powell and Zielinski, 1994). Males generally have larger territories than females– an adult

male's home range may be from 20 to 34 km^2 and may overlap those of several females. A female's home range is from 15 to 19 km^2. Home range within each sex are generally exclusive.

Landscape-scale fisher habitat requirements are not well understood, however their preference for diverse habitats created by multi-aged stands containing wetland or riparian habitat and their requirement for continuous overhead cover is well documented (Banci, 1989; Powell and Zielinski, 1994; MOF and BCE, 1997). Small forest openings created by fire and wind-throw are a natural component of fisher habitat although large, non-forested areas, such as those created by clear-cut logging, are beyond the scale of natural disturbances. Other important landscape attributes, such as stand size and shape and use of corridors, are not known (Krohn *et al.*, 1996).

LIFE REQUISITES/SEASONAL USE PATTERNS

Year-round security is the most important life requisite for fisher (Table 8). It is assumed that habitats that provide adequate cover also provide habitat for both feeding and reproduction. Additional feeding is also provided in the growing season by habitats that do not otherwise provide cover/security.

Table 8. Fisher seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Security	All seasons	All
2.	Feeding	All seasons	All
3.	Reproduction	Winter	March-April
4.	Living	All seasons	All

Security

Security is provided by continuous overhead forest cover and in structures associated with late-successional forests. Estimates of crown closures that provide suitable cover vary. Kelly (1997, as cited in Powell, 1992) and Allen (1983) agree that fisher avoid forests with less than 50% canopy closure however MOF and BCE (1997) suggests that canopies with greater than 30% are adequate.

Feeding

Suitable feeding habitat is provided in those areas that provide good security. However, fishers will also feed in areas that do not provide good year-round cover, such as younger forests and regenerating clear-cuts.

Reproduction

Habitats that provide the greatest opportunity for den sites are mature forests and riparian areas. In general, habitat that provides good security also provides habitat for reproduction. Habitat for reproduction is not rated separately in this model and is included here only for completeness.

Living

Habitat that provides living contains security and food in close proximity. These life requisites are often provided in the same habitat, however, fisher will feed in areas with sub-optimal security if there is adequate security nearby.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between fisher habitat use and TEM ecosystem and terrain attributes are described in Table 9.

HABITAT RATINGS

Rating Scheme/Modelling Theme

The fisher suitability map will depict the food (FD), security (SH) and living (LI) habitat for year-round use. A 4-class rating scheme will be used for the final suitability ratings, however, a 6-class rating scheme is used in this draft since all of the field ratings were done using this scale. LI encompasses all of the requirements necessary for survival and is a function of the spatial arrangement of FD and SH in the landscape.

Food (FD) and Security (SH) Assumptions

The ratings table assigns a suitability rating for FD and SH to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between fisher life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 10). For example, the optimal structural stage for fisher security (old forest) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 4, which would result in a max rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Table 9. Fisher habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	On a provincial scale, the study area is considered to provide up to 50% of the best habitat in the province, corresponding to a suitability rating of 3 (moderate). However, individual ratings for food and/or security may be higher.
Biogeoclimatic Zone	Fisher habitat can be found in all BGC Zones except the AT. The BWBSdk1 has the potential to be rated highest because of the greater occurrence of riparian areas. The greater snow depths in the SWBmk1, SWBmks1, ESSFmv4 and ESSFmvp4 limit their value for feeding and security in the winter.
Site Series	In general, moister site series (soil moisture regimes from mesic to subhygric) provide better fisher habitat than drier site series (very xeric to sub-mesic) and very wet site series (hygric to hydric). Moister sites typically have higher canopy closure and denser shrub and herb layers (MOF, 1996), providing better cover and prey habitat. However, very wet sites (sub-hydric to hygric) typically have a lower canopy closure, thus providing poorer security habitat. Mesic and moister sites are also likely to have higher coarse woody debris than both very wet and very dry sites.
Structural Stage	Structural stages 06 (mature forest) and 07 (old forest) represent the best year-round fisher habitat as they provide the greatest vertical and horizontal structural complexity and have the greatest likelihood of high course woody debris. Structural stage 05 (young forest) lacks some of the complexity associated with mature and old forest and is considered to provide lower quality year-round habitat. Structural stage 04 (pole-sapling) provides low-level feeding and security habitat. Structural stage 3b (tall shrub) provides low-level feeding habitat and no security. Structural stages 01 (non-vegetated/sparse), 02 (herb) and 3a (low shrub) are not considered to provide significant fisher habitat.
Coarse Woody Debris	Coarse woody debris (CWD) is an important habitat attribute for fisher however, prediction of map units with high CWD is difficult. Late successional forests are most likely to contain the highest CWD (discussed above). As well, productive, mesic series are likely to have higher CWD than both drier and wetter site series.
Riparian Areas	Riparian areas have been found to be used disproportionately more than their occurrence and are therefore emphasized in this model. Riparian areas are identified as polygons within 50m of active fluvial plains (terrain code "F^{A}p") and have SMR sub-hygric or hygric.

Living (LI) Habitat Use Assumptions

The LI rating is a combination of the FD and SH ratings. Since a given habitat can generally only be as good as the most limiting life requisite, LI is calculated as the lower rating between the polygon FD and SH rating. For complex polygons, the best rating of any decile is used for each life requisite.

Table 10. Fisher food and security habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score	
			FD-A	SH-A
1. BGC Unit	**CAR**	BWBSdk1	2	2
		ESSFmv4	2	3
		SWBmk1	3	4
		ESSFmvp4	4	4
		SWBmks1	4	5
		AT	5	5
	MIR	ESSFmv4	2	3
		ESSFmvp4	4	4
		AT	5	5
	EMR	SWBmk	3	4
		SWBmks	4	5
		AT	5	5
	WMR	BWBSdk1	2	2
		ESSFmv4	2	3
		SWBmk1	3	4
		ESSFmvp4	4	4
		SWBmks1	4	5
		AT	5	5
2a. Site Series (SMR)		Xeric	2	2
		Subxeric	1	1
		Submesic	0	0
		Mesic	0	0
		Subhygric	0	0
		Hygric	1	1
		Subhydric	2	2
		Hydric	2	2
2b. Site Series (SNR)		Very poor - poor	1	1
		Medium-very rich	0	0
3. Structural Stage		Sparse (1a)	3	3
		Bryoid (1b)	3	3
		Herb (2)	3	3
		Low shrub (3a)	3	3
		Tall shrub (3b)	2	3
		Pole/sapling (4)	2	2
		Young forest (5)	1	1
		Mature forest (6)	0	0
		Old forest (7)	0	0
4. Stand Composition		Broadleaf	1	1
		Mixed	0	0

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3.3 Lynx (*Lynx canadensis*)

SPECIES NAME: Lynx
SCIENTIFIC NAME: *Lynx canadensis*
SPECIES CODE: M-LYCA
STATUS: Not at risk (MELP, 1997, COSEWIC, 1998)

DISTRIBUTION

Provincial Range

In British Columbia, lynx are found throughout coniferous forests east of the Coast Mountains.

Provincial Benchmark

Ecoprovince: not established
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, ESSFmv4, SWBmks1, ESSFmvp4
Elevational range: Valley bottom to treeline

ECOLOGY AND HABITAT REQUIREMENTS

Lynx are commonly associated with the boreal forests of Alaska and Canada and among the isolated spruce, subalpine fir, and lodgepole pine forests in the mountains of the West (Koehler and Brittell, 1990). Lynx require a mosaic of forest conditions: early successional forests that contain high numbers of prey species (especially snowshoe hare) for foraging and mature forests for denning (Koehler and Brittell, 1990). Intermediate successional stages primarily serve as travel cover for lynx and provide connectivity within a forest landscape (Koehler and Aubry, 1994).

Snowshoe hare are the primary prey for lynx, comprising more than 60% of their diet in winter and about 40% in summer (Quinn and Parker, 1987). Lynx are so dependent on snowshoe hares that lynx density follows the 10-year hare population cycle (reviewed by Hatler, 1989).

Hare populations flourish in dense stands of young conifers or brushy deciduous growth (Ferron and Ouellet, 1992; Koehler and Brittell, 1990). Their summer diet includes a variety of forbs, grasses and small shrubs (e.g. *Salix* sp., *Acer* sp., *Populus* sp., *Betula* sp.) (Wolff 1980). During winter, snow covers low-growing plants and hares must feed on shrubs and seedlings exposed above the snow surface. Small diameter twigs and new growth (less than 0.4 inch in diameter) are preferred winter browse but larger diameter stems may be eaten when conditions become harsh and food is limited (Wolff, 1980). During snow-free periods, hares will occupy habitats that are more open and where hardwoods and herbaceous vegetation are more prevalent (Koehler and Aubry, 1994).

Koehler (1990) found that hares were most abundant in younger-aged (20 year old) stands of lodgepole pine than in any other forest type. Besides providing thermal and security cover, lodgepole pine was the primary browse for hares during winter (96% of stems browsed).

Other lynx prey items include mice, voles, squirrels, ruffed grouse and ptarmigan (Quinn and Parker, 1987). These other prey items are especially important in years when snowshoe hare are not abundant.

For natal dens, females select dense, mature forest habitats that contain large woody debris to provide security and thermal cover for kittens (Koehler, 1990; Koehler and Aubry, 1994). In north-central Washington, lynx denned in stands approximately 200 years old with Engelmann spruce-subalpine fir-lodgepole pine overstories having N-NE aspects. These sites also had a high density of downed trees (> 1/m) supported 0.3-1.2 m above the ground (Koehler, 1990). Other important features of denning sites are minimal human disturbance, proximity to feeding habitat, and stands that are at least 1 ha in size (Koehler and Brittell, 1990). Koehler and Aubry (1994) suggest that one to five acre parcels (0.5 to 2 ha) may be adequate as den sites, but these pockets of mature forests must be connected by corridors of cover. Non-maternal den sites are also found in mature forest habitats and are important as refugia from inclement winter weather or drought (Koehler and Aubry, 1994).

Suitable travel cover consists of coniferous or deciduous vegetation greater than 2m in height with a closed canopy that is adjacent to foraging habitats. During winter and summer, lynx frequently travel along roadways where adequate cover is present on both sides of the road (Koehler and Brittell, 1990).

Most daily lynx movements are for hunting and they may travel as much as 8 km in a day, depending on prey densities. Home range sizes are extremely variable and are also related to hare densities. Hatler (1988) found reported home ranges as small as 11ha and as large as 243ha.

Burning and clear-cutting may improve snowshoe hare habitat, thus improving lynx feeding habitat, however loss of forest cover removes opportunities for security, denning and movement. Movement may be especially affected since Koehler (1990) reports that lynx do not cross openings wider than 300ft (91m).

LIFE REQUISITES/SEASONAL USE PATTERNS

Lynx life requisites have been divided into food, security, denning and living (Table 11).

Table 11. Lynx seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Food (FD)	All seasons	All
2.	Security (SH)	All seasons	All
3.	Denning (DE)	Growing	June-September
4.	Living (LI)	All seasons	All

Food

Presence of snowshoe hare habitat is one of the most important factors in determining feeding habitat selection for lynx. Early successional stands (20-30 years old) dominated by lodgepole pine and spruce-subalpine fir represent the best hare habitat.

Security

Security allows movement within their home range and provides access to denning sites and feeding areas. Suitable security is provided by closed, overhead vegetation of varying types.

Denning

Denning sites are selected in dense, mature forests that contain large woody debris to provide security and thermal cover for kittens. Koehler and Aubrey (1994) report that suitable denning habitat must have feeding habitat in close proximity. For this model, we assume that denning habitat is provided in habitats with good security and it is not a limiting life requisite.

Living

Habitat that is used for daily living is a mosaic of suitable feeding and security habitats. We assume that food must be within 100m of habitat that provides security.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between lynx habitat use and TEM ecosystem and terrain attributes are described in Table 12.

Table 12. Lynx habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Lynx habitat is rated up to 50% of the best habitat in the province, corresponding to a suitability rating of 3 (moderate). Polygons may be rated higher than 3 for food or security.
Biogeoclimatic Zone	Lynx can be found in all BGC Zones, except AT. The BWBSdk1 provides the best potential feeding habitat in the study area. The greater snow depths in the SWBmk1, ESSFmv4, SWBmks1 and ESSFmvp4 limit their value for winter snowshoe hare habitat, thus decreasing their value for lynx feeding. It is assumed that the BWBSdk1, SWBmk1, and ESSFmv4 all provide the same potential for security.
Site Series	In general, sites with soil moisture regimes (SMR) sub-mesic to sub-hygric provide better lynx habitat than both drier and wetter sites. Moist sites will have higher herb and shrub cover, providing better hare habitat for feeding and better cover for security and denning. Moist sites will also have higher coarse woody debris (CWD) providing better denning habitat.
Structural Stage	Younger forested stages generally provide feeding habitat for lynx while older stages provide security and denning. Structural stages 3b (tall shrub) and 04 (pole/sapling) provide the best snowshoe hare habitat (hare are most abundant in stands between 10 and 30 yrs.) and are therefore the best lynx feeding habitat. Structural stage 3a (low shrub) provides lower-level feeding habitat because the snow cover in winter would make the majority of the vegetation inaccessible. Structural stages 06 (mature forest) and 07 (old forest) primarily provide security and denning habitat. Structural stage 05 (young forest) primarily provides security. Structural stages 01 (non-vegetated/sparse) and 02 (herb) do not provide significant habitat for hare.
Stand Composition	Broadleaf stand provide poor overhead cover in winter and are thus rated lower than coniferous stands for security.
Coarse Woody Debris	Coarse woody debris (CWD) is an important habitat attribute for lynx denning, however, prediction of map units with high CWD is difficult. Late successional forests are most likely to contain the highest CWD (discussed above) and productive, mesic series are likely to have higher CWD than both drier and wetter site series.
Proximity Effects	Habitat that provides food but have poor security must have security nearby. Given that lynx rarely cross openings larger than 91 m (Koehler, 1990), we assume that food must be within 100 m of security.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 4-class rating scheme will be used for the final suitability ratings, however, a 6-class rating scheme is used in this draft since all of the field ratings were done with this system. The ratings will be converted from the 6-class scheme to the 4-class scheme, which is most appropriate given knowledge about lynx habitat requirements. The suitability map depicts habitat for food (FD), security (SH) and living (LI) for year-round use.

FD and SH are rated for each ecosystem unit in the ratings table. LI, which is not contained in the ratings table, is a function of the spatial arrangement of FD and SH in the landscape and encompasses all of the daily requirements necessary for survival.

The model is being applied to 1:20,000 TEM, however, the final suitability maps will printed at 1:50,000.

Security (SH) and Food (FD) Habitat Assumptions

The ratings table assigns a suitability rating for FD and SH to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between lynx life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 13). For example, the optimal structural stage for lynx security (old forest) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of -2, which would result in a max rating of 3 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Living (LI) Assumptions

Lynx require habitat for both food and security. The LI rating incorporates the FD and SH ratings within the target polygon and the ratings in adjacent polygons. They are also adjusted depending on the primary use of the polygon:

- Habitats used primarily for food may only be rated as good as the best security/thermal within 100 m of the target polygon.
- Habitats used primarily for security/thermal may only be rated as good as the best food within 500 m of the target polygon.

Specifically:

- If FD > ST, then LI equals the limiting rating between the polygon FD rating and the best ST rating within 100m (including the target polygon).
- If ST > FD, then LI equals the limiting rating between the polygon ST rating and the best FD rating within 500m (including the target polygon).

Table 13. Lynx security and food habitat use assumptions. Each number represents a degrading score. A rating for an ecosystem unit is generated by summing the degrading scores over all attributes.

Attribute		Value	Degrading Score	
			FD-A	SH-A
1. BGC Unit	**CAR**	BWBSdk1	2	2
		ESSFmv4	3	2
		SWBmk1	3	2
		ESSFmvp4	5	5
		SWBmks1	5	5
		AT	5	5
	MIR	ESSFmv4	3	2
		ESSFmvp4	5	5
		AT	5	5
	EMR	SWBmk	3	2
		SWBmks	5	5
		AT	5	5
	WMR	BWBSdk1	2	2
		ESSFmv4	3	2
		SWBmk1	3	2
		ESSFmvp4	5	5
		SWBmks1	5	5
		AT	5	5
2a. Site Series (SMR)		Xeric	2	2
		Subxeric	1	1
		Submesic	0	0
		Mesic	0	0
		Subhygric	0	0
		Hygric	0	0
		Subhydric	0	1
		Hydric	2	3
2b. Site Series (SNR)		Very poor- Poor	1	1
		Medium-very rich	0	0
3. Structural Stage		Sparse (1a)	5	5
		Bryoid (1b)	5	5
		Herb (2)	5	5
		Low shrub (3a)	3	5
		Tall shrub (3b)	0	5
		Pole/sapling (4)	0	2
		Young forest (5)	2	2
		Mature forest (6)	2	0
		Old forest (7)	2	0
4. Stand Composition		Broadleaf	0	1
		Mixed	0	0

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3.4 Wolverine (*Gulo gulo*)

SPECIES NAME: Wolverine
SCIENTIFIC NAME: *Gulo gulo*
SPECIES CODE: M-GUGU
STATUS: Blue-listed (MELP, 1997); Vulnerable (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

Wolverine (*Gulo gulo*) are distributed throughout the northern boreal forests and tundra with southward extensions in the western mountains. In British Columbia, they are found throughout the mainland portion of the province and on Vancouver Island (Hatler, 1989).

Provincial Benchmark

Ecoprovince: Not established
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, ESSFmv4, SWBmks1, ESSFmvp4 and AT
Elevational range: Valley bottom to alpine

ECOLOGY AND HABITAT REQUIREMENTS

Most research has concluded that wolverine habitat is best defined by adequate year-round food availability in large, sparsely inhabited wilderness areas, rather than in terms of particular types of topography or plant associations (Banci, 1994). Wolverine habitat preferences are closely tied with ungulate carrion availability, their principal diet in winter. In fact, all studies on wolverine have shown the paramount importance of large mammal carrion and that the availability of carrion underlies their distribution, survival and reproductive success (Banci, 1994). Wolverine are scavenging predators and other important prey items, especially in the growing season, may include snowshoe hare, grouse, ptarmigan, ground squirrels, tree squirrels, mice and voles. Their diet may even include fruits, berries, insects and fish if other food items are not available (Hash, 1987).

Hatler (1989) found two consistent habitat use patterns described in the literature: an affinity for high altitude, spruce-fir forests and vertical migrations in mountainous areas. Summer is often spent at high elevations feeding on smaller prey, such as rodents, birds and berries. In winter, food becomes scarce at higher elevations and wolverines travel to where ungulates are wintering, often at lower elevations (Hatler, 1989). Wolverines do not appear to be dependent on any particular cover type, although some studies have found that forest cover provides escape from wolves (Hornocker and Hash, 1981; Hatler, 1989).

Wolverines do not return to specific daily dens, but rather select suitable locations along their travel routes. There appears to be few consistent characteristics of natal dens, except for the presence of snow cover. Natal dens have often been found in decaying logs, under rock piles and fallen trees or are simply snow tunnels (Hash, 1987).

Adult males have home ranges ranging, on average, from 240 to 670 km^2. Females have smaller home ranges, on the order of 70 to 400 km^2, depending if they are with young (Banci, 1994). These large home ranges are a consequence of their constant search for carrion, the migratory nature of many of their ungulate prey and their exceptional stamina for suspended travel over rough terrain and deep snow (Hash, 1987). Daily movements can often be 30-40 km (Banci, 1994).

LIFE REQUISITES/SEASONAL USE PATTERNS

Food

The availability of food underlies wolverine distribution. High ungulate density is the key habitat feature in winter, while high small mammal and ground bird densities are most important in the growing season. In the Mackenzie TEM study area, moose, elk and caribou are assumed to be the main ungulate prey items in winter.

Table 14. Wolverine seasonal life requisites

Rank	Life Requisite	Season	Months
1.	Food	All seasons	All months

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between wolverine habitat use and TEM ecosystem and terrain attributes are described in Table 15.

Table 15. Wolverine habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	We assume that the study area provides up to moderate wolverine habitat (corresponding to a rating of 3 on a scale of 1-6) relative to the best habitat in the province.
Biogeoclimatic Zone	Wolverines may be found in all BGC zones within the study area. The ESSFmv4 represents the best all-season habitat for wolverine and it is rated highest. The AT and parkland zones (ESSFmvp4 and SWBmks1) are used more often in summer than in winter and are therefore rated high for summer use. The SWBmk1 and BWBSdk1 are used more in the winter than in the summer as they are more likely to support wintering ungulates.
Site Series	Wolverines are closely associated with high quality ungulate habitat. As such, high rated wolverine habitat will be those site series that support the greatest ungulates. Xeric sites are rated lower than sub-xeric to hydric sites, as they produce lower quality forage.
Structural Stage	All structural stages potentially provide food for wolverine. However, structural stage 01 (non-vegetated/sparse) provides the lowest feeding potential, as there is lower forage for ungulates and lower densities of small mammal prey. Structural stages 02 (herb) provides lower winter habitat as ungulates are more likely to be found associated with shrub and forested habitats for browse and thermal protection during this season. Structural stages 03 (shrub/herb) to 07 (old forest) potentially provide habitat all year round, with older spruce/fir forests potentially providing optimal habitat.
Disturbance	Wolverine are characterised as requiring wilderness habitat and are rarely found near human activities. Thus, all areas habitat within 300 m of a highway are considered to provide no habitat for wolverine. Habitat within 300 m of a secondary road (such as a logging road) or an isolated building are rated down.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A four-class rating scheme is used to rate wolverine habitat for food (FD) in all seasons. A 6-class rating scheme is used in this draft since all of the field ratings were done with this system and ratings will be converted to the four-class scheme, which is more appropriate given the level of knowledge of wolverine habitat requirements.

The model is based entirely on feeding requirements since all studies on wolverine have shown the paramount importance of large mammal carrion and that the availability of carrion underlies their distribution, survival and reproductive success (Banci, 1994). Wolverine denning requirements are extremely broad and are assumed to be satisfied in areas that provide feeding.

Food (FD) Assumptions

The ratings table assigns a suitability rating for FD to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between wolverine life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 16). For example, the optimal structural stage for food (old forest)

has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as Bryoid) has a degrading score of -4, which would result in a max rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Table 16. Wolverine food habitat use assumptions. Each number represents a degrading score. A rating for an ecosystem unit is generated by summing the degrading scores over all attributes.

Attribute		Value	Degrading Score
			FD-A
1. BEC Unit	**CAR**	BWBSdk1	2
		ESSFmv4	2
		SWBmk1	2
		ESSFmvp4	2
		SWBmks1	2
		AT	3
	MIR	ESSFmv4	2
		ESSFmvp4	2
		AT	3
	EMR	SWBmk	2
		SWBmks	2
		AT	3
	WMR	BWBSdk1	2
		ESSFmv4	2
		SWBmk1	2
		ESSFmvp4	2
		SWBmks1	2
		AT	3
2a. Site Series (SMR)		Xeric	2
		Subxeric	1
		Submesic	0
		Mesic	0
		Subhygric	0
		Hygric	0
		Subhydric	0
		Hydric	1
2b. Site Series (SNR)		Very poor- Poor	1
		Medium-very rich	0
3. Structural Stage		Sparse (1a)	3
		Bryoid (1b)	3
		Herb (2)	0
		Low shrub (3a)	0
		Tall shrub (3b)	0
		Pole/sapling (4)	0
		Young forest (5)	0
		Mature forest (6)	0
		Old forest (7)	0
4. Stand Composition		Broadleaf	0
		Mixed	0

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3.5 Grizzly Bear (*Ursus arctos*)

SPECIES NAME: Grizzly bear
SCIENTIFIC NAME: *Ursus arctos*
SPECIES CODE: M-URAR
STATUS: Blue listed (MELP, 1997); Vulnerable (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

Grizzly bears are found throughout most of mainland British Columbia. They have been extirpated from areas that are intensively farmed or urbanized, including the Lower Mainland, Thompson-Okanagan, Cariboo and Peace River areas. Grizzlies are not found on the coastal islands of BC (Fuhr and Demarchi, 1990).

Provincial Benchmark

Ecoprovince: Not established
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, ESSFmv4, SWBmks1, ESSFmvp4, and AT
Elevational range: Valley bottom to alpine

ECOLOGY AND HABITAT REQUIREMENTS

Grizzly bears are highly mobile omnivores with large spatial requirements. Grasslands and shrublands integrated with forests, subalpine meadows and forests, and alpine communities are typical grizzly habitat (Nietfeld *et al*., 1985). Their range encompass habitats that provide a sequence of abundant foods and alternate food sources.

Grizzlies feed on a wide variety of plants, switching during the year depending on availability and abundance (Fuhr and Demarchi, 1990). Grizzly diet in spring and early summer consists mainly of forbs, such as horsetail, cow parsnip, and glacier lily, and grasses and sedges and other green vegetation (Stevens and Lofts, 1988). Moist fens and streamsides produce high densities

of prime summer vegetation (Nietfeld *et al*., 1985). In late summer and fall, berries such as huckleberries, blueberries, soopolallie, and currants are an important component of their diet although roots, grasses and forbs continue to be consumed (Nietfeld *et al*., 1985).

Ridgetops , talus slopes, avalanche chutes, creek/river bottoms, fluvial and alluvial floodplains, and river/stream sides are seasonally important foraging areas (Craighead *et. al.,* 1982, Erickson, 1976). Riparian habitats provide aquatic vegetation types such as sedges and horse-tails (Craighead *et. al*., 1982, Martinka, 1976) and anthropogenic sites such as reclaimed well sites, pipelines and road sites are also utilised seasonally (Nagy, 1984). Most of the latter sites are subject to frequent or recent disturbances and therefore support early succession vegetation forms favoured by grizzly. In general, combinations of terrain and vegetation forming mosaics of forests, shrublands, grasslands and meadows, and riparian regions provide an interspersed array of habitats for the grizzly bear (Martinka, 1976). Grizzlies locate and learn to use specific locales where plant food are abundant; the most productive sites become centres of activity within the home range (Craighead *et. al.,* 1982).

Avalanche paths are key feeding habitats for grizzly but not all avalanche paths are used. Low use paths are often found in the mesic or drier classes while the high use paths are found in the sub-hygric or wetter classes. The lusher sites are often located on southwest aspects (Simpson, 1987). Other important feeding areas may include logged areas where food is potentially abundant (Simpson, 1987). In general, seral plant communities are important feeding habitat for grizzly bear (Humer and Herrero, 1983).

Animal matter such as ants, ground squirrels, and young, weak or old ungulates are also taken opportunistically. Animal protein sources may concentrate grizzly use on small areas such as fish spawning areas or rodent colonies (Fuhr and Demarchi, 1990).

In addition to suitable feeding areas, grizzlies require cover for security and bedding. Cover is generally provided in forested habitats. Simpson (1987) found that bedding sites averaged a canopy closure of 59% compared to an average of 28% for feeding areas. Simpson (1987) also noted that forest cover adjacent to avalanche paths was mainly composed of cedar (66%) followed by hemlock (26%) and spruce (8%). Security cover is most likely not a limiting factor in wilderness areas except in areas of resource development such as logging operations, and oil and gas exploration with associated road construction, all of which may increase hunting pressure (Nietfeld *et al*., 1985). Nietfeld *et al*. (1985) also report that adequate security cover to reduce visual contact by man is provided in vegetation and/or topography which hides 90% of a grizzly from view of a person 122m away. Habitats that provide cover should also have a diameter of at least 91m.

Grizzly den sites vary from alpine/subalpine talus slopes, shrubfields and krummholz areas to various timbered subalpine and lowland areas (Aune, 1994). Most dens are located to ensure an early and long-lasting snow cover for insulation. Dens tend to be located on slopes allowing for ease of digging, mostly ranging from 25-40º. Dens are usually located in areas were soils are well drained to prevent internal flooding and in soils cohesive enough to maintain the physical stability of the den during the first winter (Nietfeld *et al*., 1985).

Mountain valley bottoms and ridgetops serve as travel corridors throughout a grizzly's home range (Russel *et. al.*,1978, Zager *et. al.*, 1980). Corridors connect different habitat units, preventing isolation and enables bears to travel to key food sources (Jonkel, 1987). A corridor may not necessarily contain food, water, or denning habitat.

The major factor determining movement and home range size for grizzlies is the abundance and distribution of food (Macey, 1979). In areas where food and cover are abundant, grizzly home ranges can be as small as 24 km^2; where food resources are scattered, the ranges must be at least ten times larger to provide an adequate food base (LeFranc *et al.*, 1987). Ranges vary greatly in area depending on the sex and age of the animal, seasonal and annual food availability, reproductive condition of females, as well as habitat type and population densities (Nietfeld *et al*., 1985).

LIFE REQUISITES/SEASONAL USE PATTERNS

In this model, grizzly life requisites are divided into food, security and denning (Table 17).

Table 17. Grizzly bear seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Food	Spring	June
2.	Food	Summer/Fall	July to September
3.	Security	Spring and Summer/Fall	June to September
4.	Denning	Winter	October to May
5.	Living	Spring and Summer/Fall	June July to September

Food

The availability and abundance is considered the single most important factor determining habitat selection for grizzly. Optimal food is provided in mesic and wetter herbaceous and shrub communities adjacent to security habitat. Food habitats in spring are generally at low elevations with early green up. Food habitats in summer are at mid to high elevations with high plant productivity and high berry production.

Security

Security is provided by closed canopy forest and cover that can hide 90% of a grizzly from 120 m away and late successional stage areas that have a canopy closure greater than 50%. Security may also be provided by terrain that provides concealment, such as that provided by gullied, ridged or undulating topography. Security habitat provides two functions: (1) conceament and escape while feeding and, (2) concealment during movement or migration.

Denning

Dens are generally located at high elevations in areas of high snowfall and low snowmelt. Dens may be located in natural caves, hollows under the roots of trees or they may excavated into the banks of steep slopes (Province of British Columbia, undated). Those dens that are excavated tend to be located on slopes mostly ranging from 55-90% slopes (Nietfeld *et al.*, 1985).

Living

Habitat that is used for general living is a mosaic of habitats that provide food and security in close proximity. We assume that food habitats must have security within 100m.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between grizzly habitat use and TEM ecosystem and terrain attributes are described in Table 18.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A six-class rating scheme is used to rate grizzly bear habitat for food (FD), security (SH) and living (LI) in the spring (P) and summer/fall (S). The LI rating is an integration of grizzly food and security requirements and more directly reflects where grizzly are likely to be found, assuming they are present in the area. A GIS algorithm uses the ratings for FD and SH and incorporates the spatial arrangement of ratings in adjacent polygons.

FD and SH are rated for each ecosystem unit in the ratings table. All ecosystem units are rated for spring and summer use. Denning habitat is not rated in this model as grizzly distribution is more dependent on the availability of adequate food and security than on the availability of den sites.

Food (FD) and Security (SH) Habitat Assumptions

The ratings table assigns a suitability rating for FD and SH to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between grizzly life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 19). For example, the optimal structural stage for security (old forest) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 2, which would result in a maximum rating of 3 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Table 18. Grizzly habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	We assume that the study area provides up to moderately high grizzly bear habitat (corresponding to a rating of 2 on a scale of 1-6), relative to the best habitat in the province. This is based on grizzly habitat potential for each Ecoregion unit estimated by Fuhr and Demarchi (1990). Habitats may be provide individual life requisites (such as food or security) exceeding the overall rating.
Biogeoclimatic Zone	Grizzlies may be found in all of the sub-zones within the study area and their use of each zone is seasonally dependent. After den emergence, grizzlies descend to lower elevations (BWBSdk1) to access early green vegetation. With increasing late-spring and summer temperatures, grizzlies are able to access green vegetation at higher elevations (SWBmk1, SWBmkp, ESSFmv4, ESSFmvp4 and AT). Salmon are not considered to be diet items for grizzlies in the study area as none of the watercourses are salmon bearing.
Site Series	Moister sites (mesic to hygric) are rated higher than drier sites (very xeric to sub-mesic) for food as they have higher plant productivity for forage. Hydric and wetter sites have lower tree cover, thus providing less security. Sites with very poor soil nutrient regime (SNR) provided lower plant productivity for food.
Site Modifier	Warm southerly and westerly aspects (135-285 degrees) provide higher quality spring and summer feeding.
Structural Stage	The optimal food and security habitats for grizzly lie at opposite ends of the successional scale– the best areas to find food are young structural stages while the best security habitat are present in more mature stages. Structural stage 02 to 3b (herbaceous to tall shrub) primarily provide food habitat. The best food habitat is provided in structural stages 02 and 3a (herbaceous and low shrub) where herbaceous plants and berry-producing shrubs can achieve their highest density. Structural stages 04 and 05 (pole sapling to young forest) provide poor food and security and are generally rated low for both. Structural stages 06 and 07 (mature forest to old forest) provide optimal security. Structural stage 01 (non-vegetated) provides no significant food or security.
Terrain Surface Expression	Security may be provided by terrain that affords concealment, such as gullied, ridged or undulating topography. Therefore, non-forested areas that would normally provide no security, are rated higher than similar polygons lacking concealing topography.
Canopy Closure	Sites with high canopy closure provide optimal security. The effect of canopy closure has been incorporated into the site series assumptions described above.
Proximity Effects	While feeding, grizzlies require security in close proximity. Therefore, habitats that provide primarily food, must have security within 100m.

Polygon Food (FD) and Security (SH) Adjustments

Adjustments are used to modify the ratings in order to account for habitat attributes that are not inherent features of the ecosystem unit (Table 20).

Living (LI) Habitat Assumptions

The seasonal living ratings (spring and summer) are each equal to the limiting rating (lower rating) between the polygon FD rating and the best SH rating in all adjacent polygons, including the target polygon. For complex polygons, the best ratings are selected from any decile.

An overall rating for the growing season was also calculated. This is equal to the best seasonal living rating. This rating is shown on the printed maps.

Table 19. Grizzly bear food and security habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score		
			FD-P	FD-S	SH-G
1. BGC Unit	**CAR**	BWBSdk1	1	2	0
		ESSFmv4	2	1	0
		SWBmk1	2	1	0
		ESSFmvp4	3	1	2
		SWBmks1	3	1	2
		AT	5	1	4
	MIR	ESSFmv4	2	1	0
		ESSFmvp4	3	1	2
		AT	5	1	4
	EMR	SWBmk	2	1	0
		SWBmks	3	1	2
		AT	5	1	4
	WMR	BWBSdk1	1	2	0
		ESSFmv4	2	1	0
		SWBmk1	2	1	0
		ESSFmvp4	3	1	2
		SWBmks1	3	1	2
		AT	5	1	4
2a. Site Series (SMR)		Xeric	2	2	1
		Subxeric	1	1	1
		Submesic	0	0	0
		Mesic	0	0	0
		Subhygric	0	0	0
		Hygric	0	0	1
		Subhydric	0	0	1
		Hydric	0	0	2
2b. Site Series (SNR)		Very poor	1	1	0
		Poor – very rich	0	0	0
3. Site Modifier		Cool aspect	1	1	0
4. Structural Stage		Sparse (1a)	4	4	4
		Bryoid (1b)	4	4	4
		Herb (2)	0	0	4
		Low shrub (3a)	0	0	3
		Tall shrub (3b)	2	3	2
		Pole/sapling (4)	3	3	2
		Young forest (5)	3	3	1
		Mature forest (6)	3	3	0
		Old forest (7)	2	2	0
5. Stand Composition		Broadleaf	0	0	0
		Mixed	0	0	0

Table 20. Polygon-specific food and security ratings adjustments for grizzly.

Topic	Description
A. Terrain surface expression	Polygons lacking forest cover (structural stages 1a, 1b, 2, 3a and 3b) are rated up 2 SH for growing and winter if the surface expression is ridged (r), undulating (u) or hummocky (h).

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3.6 Moose (*Alces alces*)

SPECIES NAME: Moose
SCIENTIFIC NAME: *Alces alces*
SPECIES CODE: M-ALAL
STATUS: Not at risk (MELP, 1997; COSEWIC, 1998)

DISTRIBUTION

Moose are found across northern Europe and Asia from Scandinavia to the Pacific coast and across northern North America from Alaska to Newfoundland and Maine (Banfield, 1974).

Provincial Range

Moose are widespread throughout the mainland of the province, excluding the coastal areas and the arid region centered in the Okanagan Valley. Most abundant provincially in the central and northern portion of the province. Before 1900, moose were absent from most of the central and southern part of the province (Nagorsen 1990).

Alces alces andersoni, one of three moose subspecies in the province (*A. a. americana, A. a. andersoni* and *A. a. shirasi*) ranges from northern Minnesota and Michigan to British Columbia, the Yukon Territory and NWT. It occupies regions east of the coastal mountain ranges except for the extreme northwest and southeast (Nagorsen 1990).

Provincial Benchmark

Ecoprovince: Boreal Plains
Ecoregion: Alberta Plateau
Ecosection: Peace Lowland (PEL)
Biogeoclimatic zone: BWBSmw
Broad Ecosystem Units: Boreal White Spruce-Trembling Aspen in winter and White Spruce-Balsam Poplar Riparian in growing

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, ESSFmv4, SWBmks1, ESSFmvp4 and AT
Elevational range: Valley bottom to alpine

ECOLOGY AND HABITAT REQUIREMENTS

Moose are generalist herbivores that feed on herbaceous plants, leaves and new growth of shrubs and trees in summer and twigs of woody vegetation during winter (Jackson *et al.*, 1991). They occupy a range of habitat types within forested communities, favouring immature forest shrubland for food and dense, woody forest areas for cover (Nietfeld *et al*., 1985; Cairns and Telfer, 1980).

In winter, the most commonly consumed food is willow. Twigs of aspen, serviceberry, maple, birch, and red osier dogwood are also eaten in great quantities. Leaves and twigs of falsebox are a second favored winter food, but this small shrub is usually buried deep under the snow. Conifers such as spruce and lodgepole pine will not sustain moose, although some types of fir and yew are eaten readily (Allen *et. al.*, 1987; Cushwa *et.al.*, 1976; Edwards, 1985; LeResche *et. al.*, 1974; Peterson, 1955; Pierce, 1984; Ritchie, 1978 and Spencer *et. al.*, 1964). Bark may be stripped off larger trees, especially in late winter and early spring when food is in short supply (Nietfeld *et al*., 1985).

Depth, density and hardness of snow is an important factor limiting suitability and availability of certain habitat for moose in the critical winter months (Franzmann, 1978). Nietfeld *et al*. (1985) reports that moose in Alberta tend to avoid areas with greater than 65-75 cm of snow. Eastman (1977) found that moose move into forested habitats in mid-winter when snow depths approached 80cm. Collins and Helm (1997) found that lower shrubs became unavailable when snow depths exceeded 110 cm.

Floodplains are the mainstay habitat for moose during severe winters, particularly in areas where lack of recent disturbance in upland forests has led to a decline in browse availability (Simkin, 1975; Bishop and Rausch, 1975). Moose are attracted to uplands disturbed by recent fires, homestead or subdivision clearing and right-of-way construction (Collins and Helm, 1997).

Hatler (1990), in a winter survey in the northern Williston Reservoir Area, reports most moose using burns with secondary levels of use in upland deciduous, riparian shrub and mixed forest habitats. Mean elevations for all habitats was less than 980 m .

During summer, moose diet includes many aquatics, forbs, grasses, and the foliage of many of the trees eaten in winter (Banfield, 1974). Moose are attracted to weedy lakes, marshes and sluggish streams where they can feed on aquatic vegetation (Nietfeld *et al*., 1985). In aquatic feeding, they may feed on sedges or horsetails in shallow water or on bur-reeds that float on the surface and may dive deeply for pondweeds or water lilies (MELP, undated).

Disturbances, such as fire and clearcutting, return forests to earlier successional stages that usually provide abundant browse. Burn areas generally provide the most suitable moose browse after 10-15 years, the length of time varying with the time of year of the burn and its intensity. The beneficial effects of fire on moose habitat are estimated to last less than 50 years with moose density peaking 20 to 25 years following the fire (LeResche and Davis, 1974). Wolf and Zasada (1979) reported that aspen provided the most browse for moose 1 to 5 years after fire, while birch and willow provided the most 10 to 16 years after fire. MacCracken and Vierek (1990)

report that following a spring fire, moose browse was abundant within two months. Discontinuous forest mosaic created by fire or timber harvest enhance "edge effect" increasing diversity of plant species favoured by moose and staggers plant maturation rate of various seral stages.

Dense, mature, coniferous forest is utilised as shelter from severe winter conditions as well as escape from harassment by insects during summer. Moose escape the summer heat by spending much of their time in the water, in cool timbered areas, or by retreating to high mountainous areas. Moose do not thrive in hot dry regions (MELP, undated). During summer, moose select tree muskegs and immature aspen stands greater than 10 m in height for cover.

Boreal white spruce forests, white spruce-subalpine fir forests, wet interior white spruce forests, deciduous riparian forest, boreal spruce-trembling aspen mixed forests, trembling aspen forests, and birch-willow scrub parkland are also important. Other forested habitats such as Engelmann spruce-subalpine fir forests and Douglas fir-lodgepole pine forests are also used but mostly for cover. The mature forested habitats, wetland habitats, avalanche shrubland, and alpine/subalpine meadows with gentle terrain are important in the summer for food and general living (Stevens and Lofts, 1988). Eastman (1977) found that moose in north-central BC used partial cut-overs and burns more than coniferous forest; deciduous forests and clearcuts were used least.

Moose generally make seasonal movements between winter range (December to March) and summer range (April to November), coinciding with spring thaw and freeze-up but they retain the same home range year after year (Nietfeld *et al*., 1985). In mountainous terrain, seasonal migrations are limited to up and down the mountain slopes and wintering in the valleys. Moose move into winter ranges before snow depths become limiting. Occasionally lone bulls winter high up on old avalanche slides where there has been thick regeneration of willows (Banfield, 1974).

Habitat sizes for the moose vary considerably with geographic location. On average, moose annual home range in northern Alberta and southern Alaska are approximately 568 – 638 km^2 (Novak *et al.*, 1987). In British Columbia, average moose ranges in summer are 218.9 ± 38 ha for males and 615.2 ±629.4 ha for females and in winter, 576.5 ± 365.8 ha for males and 596.2 ± 450.9 ha for females (Schwab, 1985, as cited in Stevens and Lofts, 1998).

LIFE REQUISITES/SEASONAL USE PATTERNS

In this model, moose life requisites are divided into food, security, thermal and living (Table 21).

Table 21. Moose seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Food	Winter	October to May
2.	Security/Thermal	Winter	October to May
3.	Food	Growing	June to September
4.	Security/Thermal	Growing	June to September
5.	Living	Winter, Growing	October to May, June to September

Food

Immature forest shrubland provides optimal food in winter. These areas, plus aquatic and wetland habitats provide optimal food in summer. Burn and clearcut areas generally provide high quality browse after 10-15 years. Young burned (70-year-old) aspen-white spruce-black spruce stands produce 10 times more forage than older stands (130 to 180 years old) (MacCracken and Viereck, 1990).

Security/Thermal

Security and thermal protection is provided by forest cover. In winter, dense, mature coniferous forest provides shelter from low temperatures and wind. Mature stands provide both thermal benefits and good snow interception because of their multi-layered structure and the deep, spreading crowns of the older trees. In summer, moose often use these thermal shelter areas to escape heat, although we assume that thermal habitat requirements are most important in winter. Ideal winter thermal habitat habitat is composed of conifers taller than 6 m, with a canopy closure of 75 percent or greater (Allen *et. al.* 1987, Timmerman and McNichol, 1988, Krefting, 1974). Schwab and Pitt (1991) suggest that optimal canopy closure should be 70% in a mature forest and to escape winter wind chill factors and high summer temperatures.

Security may also be provided by concealing topography, such as that provided in gullied, ridged and hummocky terrain.

Living

Ideal moose habitat contains an interspersion of food and security/thermal habitat. We assume that food and security must be within 200m of each other.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between moose habitat use and TEM ecosystem and terrain attributes are described in Table 22.

Table 22. Moose habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Moose occur in all four Ecosections ion the Study Area. Based on overview capability mapping (habitat Inventory Branch, 1994), these Ecosections provide up to moderately high moose habitat, corresponding to a suitability rating of 2. Individual ratings for FD and ST may be higher. The WMR, MIR and EMR provide only low-level winter habitat whereas the CAR supports moose year-round.
Biogeoclimatic Zone	Moose potentially occur in all of the BGC zones and sub-zones/variants in the study area. Higher elevation zones provide poorer habitat than that BWBSmw2, especially in winter. AT provides habitat in the growing season only.
Site Series	In general, moister site series (soil moisture regimes from mesic to subhydric) provide better moose habitat than drier site series (very xeric to sub-mesic) in each of the BGC sub-zones present in the study area. Moisture sites typically have a higher canopy closure and denser shrub and herb layers which provides good thermal cover.
Site Modifier	Warm aspects typically have lower snow depths and therefore provide more abundant food in winter.
Structural Stage	Early successional forests provide feeding habitat whereas young to mature forests provide good security and thermal protection. Older forests are important for food in winter as their snow high snow interception allows for easy access to food. Shrub structural stages provide optimal food but low security/thermal protection. Young to mature forests provide optimal thermal protection. Old-growth forests usually have low crown closure which allows good shrub growth but intercepts snow poorly and provides poor thermal protection.
Stand Composition	In winter, broadleaf and mixed stands provide poorer security and thermal protection than conifer stands. Coniferous shrub habitats (regenerating conifers) provide lower food in growing and winter.
Terrain	Terrain that provides concealment, such as that provided by gullied, ridged or undulating topography, provides security. Therefore, non-forested areas that would normally provide no security, are rated higher than similar polygons lacking concealing topography.
Proximity Effects	Habitats that provide food must have security/thermal protection within 200m.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 6-class rating scheme is used to rate moose habitat. Food (FD), security/thermal (ST) and living (LI) are rated for use in the growing and winter seasons. LI encompasses all of the requirements necessary for survival and is a function of the spatial arrangement of FD and ST in the landscape.

Food (FD) and Security/Thermal (ST) Habitat Assumptions

The ratings table assigns a suitability rating for FD and ST to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between moose life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 23). For example, the optimal structural stage for food (low shrub) has a degrading score of "0"– no degrading effect. However, a sub-optimal

Table 23. Moose food and security/thermal habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score			
			FD-G	ST-G	FD-W	ST-W
1. BGC Unit	**CAR**	BWBSdk1	1	1	1	1
		ESSFmv4	1	1	2	2
		SWBmk1	1	1	2	2
		ESSFmvp4	1	2	3	4
		SWBmks1	1	2	3	5
		AT	2	4	5	5
	MIR	ESSFmv4	1	1	2	2
		ESSFmvp4	1	2	3	4
		AT	2	4	5	5
	EMR	SWBmk	1	1	3	3
		SWBmks	1	2	4	5
		AT	2	4	5	5
	WMR	BWBSdk1	1	1	1	1
		ESSFmv4	1	1	2	2
		SWBmk1	1	1	2	2
		ESSFmvp4	1	2	3	4
		SWBmks1	1	2	3	3
		AT	2	4	5	5
2a. Site Series (SMR)		Xeric	2	2	2	2
		Subxeric	1	1	1	1
		Submesic	0	0	0	0
		Mesic	0	0	0	0
		Subhygric	0	0	0	0
		Hygric	0	0	0	1
		Subhydric	0	1	0	2
		Hydric	0	1	0	3
2b. Site Series (SNR)		Very poor- Poor	1	1	1	1
		Medium-very rich	0	0	0	0
3. Site Modifier		Cool aspect (k)	0	0	1	0
4. Structural Stage		Sparse (1a)	5	5	5	5
		Bryoid (1b)	5	5	5	5
		Herb (2)	2	5	4	5
		Low shrub (3a)	0	5	0	5
		Tall shrub (3b)	0	1	0	2
		Pole/sapling (4)	3	0	3	0
		Young forest (5)	3	0	3	0
		Mature forest (6)	3	0	2	0
		Old forest (7)	3	0	2	0
5. Stand Composition		Broadleaf (B)	0	0	0	2
		Mixed (M)	0	0	0	1
		Conifer (C)	0 (1)[a]	0	0 (1)[a]	0

[a] Conditional rating: if structural stage is low shrub or tall shrub, then down-rating adjustment equals -1.

structural stage (such as pole-sapling) has a degrading score of 4, which would result in a maximum rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Polygon Food (FD) and Security/Thermal (ST) Adjustments

Polygon-specific adjustments (Table 24) are used to modify the ratings in order to account for moose habitat attributes that are not inherent features of the ecosystem unit.

Living (LI) Habitat Assumptions/Adjustments

Moose require habitat for both food and security/thermal. The LI rating incorporates the FD and ST ratings within the target polygon and the ratings in adjacent polygons.

They are also adjusted depending on the primary use of the polygon:

- Habitats used primarily for food may only be rated as good as the best security/thermal within 200 m of the target polygon.
- Habitats used primarily for security/thermal may only be rated as good as the best food within 200 m of the target polygon.

Specifically:

- If FD > ST, then LI equals the limiting rating between the polygon FD rating and the best ST rating within 200m (including the target polygon).
- If ST > FD, then LI equals the limiting rating between the polygon ST rating and the best FD rating within 200m (including the target polygon).

For complex polygons, the highest rating of the first two deciles is selected.

Table 24. Polygon-specific food and security/thermal ratings adjustments for moose.

Topic	Description
A. Terrain surface expression	Polygons lacking forest cover (structural stages 1a, 1b, 2, 3a and 3b) are rated up 2 ST for growing and winter if the surface expression is ridged (r), undulating (u) or hummocky (h).

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3.7 Rocky Mountain Elk (*Cervus elaphus nelsoni*)

SPECIES NAME: Rocky mountain elk
SCIENTIFIC NAME: *Cervus elaphus nelsoni*
SPECIES CODES: M-CEEL
STATUS: Not at risk (MELP, 1997; COSEWIC, 1998)

DISTRIBUTION

Provincial Range

Rocky Mountain elk primarily occur in the Kootenays, the lower Peace River area and the Muskwa-Prophet River drainages on the eastern slope of the Rocky Mountains. Although Rocky Mountain elk were historically abundant and widely distributed in the Cariboo-Chilcotin and Thompson-Nicola areas, elk declined for unknown reasons and today only small, widely scattered herds remain in these areas.

Provincial Benchmark

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Muskwa Foothils (MUF)
Biogeoclimatic zone: SWBmk
Broad Ecosystem Units: SM - Subalpine Meadow

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, ESSFmv4, SWBmks1, ESSFmvp4 and AT
Elevational range: Valley bottom to alpine

The Akie and Pesika River drainages contain small populations of elk (Wood, 1994; Hatler, 1990; Wood, pers. comm.). The summer population is larger due to seasonal migrations from the Muskwa/Prophet river drainages and other adjacent areas (Wood, pers. comm.). Hatler (1990) and Wildlife Branch (1990b) found 22 and 19 elk respectively wintering in the upper Akie River drainage.

A small population of elk reside along the Ingenika River. In 1996, 50 elk were transplanted into this area to supplement the original population of 20 to 30. The population is currently estimated at 40 to 50 individuals (Wood, pers. comm.)

ECOLOGY AND HABITAT REQUIREMENTS

Elk are habitat and diet generalists. They are good dispersers and rapidly exploit newly created habitats (Geist, 1982 in Singer and Norland, 1994). Elk require areas for food and cover, winter and summer and winter ranges (containing suitable food and cover), rutting, calving, migration routes and mineral licks (Fish and Wildlife Branch, 1981). Early successional stages and forest openings provide feeding habitat while forest cover provides security and thermal protection. They are often associated with the boundaries or ecotones between forest and non-forest ecosystems as this provide great abundance and diversity of forage with close proximity to cover (Skovlin, 1982).

Elk are migratory, spending winters in low elevation ranges and summers in higher elevation upland areas. The migration movements are primarily a function of vegetation availability in relation to snow depth. In the growing season, elk are grazers, preferring early successional stages, including grasslands, parkland, avalanche tracts, clear-cuts, burns, roadsides and forest openings. Grasses and sedges are eaten extensively and will be used year-round, if available. Broad-leaved herbaceous plants are also used extensively (Nietfeld *et al.*, 1985). Browse may be an important part of the summer diet, depending on the availability of grasses and forbs. (Fish and Wildlife Branch, 1981).

In winter, snow cover limits ground level forage and elk are forced to browse on deciduous trees and shrubs. Preferred winter browse species include Saskatoon (*Amalanchier alnifolia*), water birch (*Betula occidentalis*) and trembling aspen (*Betula tremuloides*) (Nietfeld *et al.*, 1985). Conifers, with the exception of spruce, are also utilised. Snow-free areas associated with southerly aspects and periodic chinook weather provide the greatest access to forage in winter and spring (Carr, 1972).
In agricultural areas, cultivated crops may provide significant amounts of forage in fall and winter.

Snow depth is the factor most limiting to elk distribution and movement. Elk movements apparently begin to be restricted by snow depths in excess of 46 cm (Beall, 1974). Snow depth limits forage availability in winter, and at depths > 61 cm, browsing will replace grazing (Skovlin, 1982).

Seasonal use of aspect is determined largely by forage availability, thermal comfort factors, and cover type. Thermal forest cover on upper north-facing slopes provides the coolest habitat during the summer and the most succulent, high quality forage into autumn months (Skovlin, 1982; Nietfeld, *et al.*, 1985). Skovlin (1982) states that many investigators have reported that elk prefer southern to southwestern exposures in winter and spring. South-facing aspects are seldom selected in summer. Sites which are protected by topography or dense vegetation are often sought out during the winter or early spring because these areas provide a refuge from strong winds, crusting or drifting snow.

Wood (1994), Wildlife Branch (1990b) and Hatler (1990) all report elk on south aspects in winter in the Mackenzie TEM study area. Hatler (1990) found almost all elk wintering in burns, on relatively open, steep, deciduous-dominated south-facing slopes.

Forest cover provides both cover and thermal protection. McNamee *et al.* (1981) characterised escape cover for elk as vegetation over 2 m with a stem density of between 50 and 2000 stems/ha while Black *et al.* (1976) states that vegetation capable of hiding 90% of an elk from a human at 61m as preferred. In winter, elk require thermal protection from low temperatures and is provided best in conifer stands with continuous closed canopies (Skovlin, 1982). Closely stocked stands of coniferous forest, 12 m or greater with high stem densities and an average canopy closure exceeding 70%, are used in winters characterised by very deep snow cover (Black *et al.* 1979; Skovlin, 1982).

Good interspersion and juxtaposition of food and cover components is important and is provided by irregular topography and parkland or forest/meadow vegetation cover (*Black et. al.*, 1979). Valley and riparian habitats are important as travel corridors between high elevation summer range and low elevation winter range; stringer forest stands also provide protected travel lanes during migration (Black *et. al.*, 1979).

Elk use gradually increases with increasing slope, to a maximum of 30-40%. The most frequently used slopes appear to be in the 15-30% class (Skovlin, 1982). A threshold in slope use appears between about 40-50%, after which elk use tends to diminish sharply (Nietfeld *et al.*, 1985).

Rutting occurs in September through October and calves are generally born in late May or June (Fish and Wildlife Branch, 1981). Calving sites usually occur on transitional spring or fall ranges or even on upper elevation winter ranges. Site selection is extremely variable: some cows will select a very secluded area with high cover while others are much less selective (Skovlin, 1982). .

Elk have a greater digestive capacity (larger rumen to body size ratio) than the smaller North American ungulates (such as mule deer and bighorn sheep) suggesting that elk may compete more successfully in poor range conditions (Collins and Urness, 1983 in Singer and Norland, 1994).

LIFE REQUISITES/SEASONAL USE PATTERNS

In this model, elk life requisites are divided into food, security/thermal and living (Table 25).

Table 25. Elk seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Food	Winter	October to May
2.	Security/Thermal	Winter	October to May
3.	Food	Growing	June to September
4.	Security/Thermal	Growing	June to September
5.	Living	Winter	October to May
6.	Living	Growing	June to September

Food

In winter, food availability in relation to snow is the most important factor limiting elk distribution.
Snow-free areas associated with southerly aspects and periodic Chinook weather provide the greatest access to forage in the winter and spring. Winter feeding habitats are primarily low elevation grassy or shrubby openings in open stands of various timber types on warm south and west aspects. Low-elevation, recent burns provide particularly good food.

In the growing season, optimal feeding habitats are early successional stages, including grasslands, parkland, avalanche tracts, clear-cuts, burns, wetlands, riparian habitats, roadsides and forest openings, primarily at higher elevations.

Security/Thermal

Security and thermal protection are both provided by forested habitats. Security may be satisfied by vegetation over 2 m. This may occur in a variety of structural stages but those with a dense understory are optimal. Security may also be provided by concealing topography, such as that provided in gullied, ridged and hummocky terrain. Closed canopy coniferous stands provide thermal cover in winter. Dense vegetation over 12m in height with a canopy closure of greater than 70% is assumed to provide optimal thermal protection.

Living

Habitat that provides living in the growing season and in the winter are those areas containing food and security/thermal in close proximity. Black *et al.* (1979) reports that most elk occur within 183 m of cover. Areas that provide living habitat year-round have suitable summer and winter ranges.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between elk habitat use and TEM ecosystem and terrain attributes are described in Table 26.

Table 26. Elk habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Elk potentially occur in all four Ecosections. The WMR, EMR and MIR generally contain little wintering habitat. Based on overview capability mapping (Habitat Inventory Branch, 1994), these Ecosections provide up to moderate elk habitat, corresponding to a suitability rating of 3. Individual ratings for FD and ST may be higher.
Biogeoclimatic Zone	Elk habitat is found in all BGC zones. BWBSdk1 provides the best habitat in winter and is also used in the growing season. The SWBmk1 and the ESSFmv4 provide primarily growing season habitat; high snow depths limit the amount of winter habitat. The SWBmks1, ESSFmvp4 and AT provide habitat in the growing season, provided there is adequate forest cover for security.
Site Series	A variety of site series with a range of soil moisture regimes produce good forage. However, moister areas (sub-mesic to mesic) tend to produce better forb diversity and quantity during the growing season and optimal thermal protection in winter. Both drier and wetter sites have lower canopy closure than the mesic sites and therefore provide poorer thermal protection during the winter.
Structural Stage	Younger structural stages generally provide the best feeding habitat where older, forested stages provide security/thermal habitat. Structural stages 02 to 3a (herbaceous to low shrub) provide optimal food year-round. Structural stage 02 is rated lower in winter (because forbs and grasses may be inaccessible under the snowpack) unless located on a warm-aspect slope. Structural stage 3b (tall shrub) provides moderate food habitat in both growing and winter. Structural stages 04 to 07 (pole sapling to old forest) provide low food in the growing season and low to moderate food in winter. Security/thermal habitat is provided in stages 04 (pole/sapling) to 07 (old forest). Optimal thermal habitat is provided in stages 05 (young forest) to 07 (old forest).
Stand Composition	Conifer dominated canopies (>75%) provide optimal thermal protection in winter. Mixedwood and broadleaf habitats provide moderate and low levels of thermal habitat respectively and are thus rated lower.
Site Modifer	Cool aspects are rated lower for food and security/thermal in winter.
Terrain Surface Expression	Terrain that provides concealment, such as that provided by gullied, ridged or undulating topography, provides security. Therefore, non-forested areas that would normally provide no security, are rated higher than similar polygons lacking concealing topography.
Proximity Effects	Habitats that provide food must be within 200m of habitats that provide security/thermal.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 6-class rating scheme is used to rate elk habitat. Food (FD), security/thermal (ST) and living (LI) are rated for use in the growing and winter seasons. LI encompasses all of the requirements necessary for survival and is a function of the spatial arrangement of FD and ST in the landscape.

Food (FD) and Security/Thermal (ST) Habitat Assumptions

The ratings table assigns a suitability rating for FD and ST to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between elk

life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 27). For example, the optimal structural stage for food (low shrub) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 4, which would result in a maximum rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Food (FD) and Security/Thermal (ST) Habitat Adjustments

Adjustments are used to modify the ratings in order to account for elk habitat attributes that are not inherent features of the ecosystem unit (Table 28).

Living (LI) Habitat Assumptions

Elk require habitat for both food and security/thermal. The LI rating incorporates the FD and ST ratings within the target polygon and the ratings in adjacent polygons. They are also adjusted depending on the primary use of the polygon:

- Habitats used primarily for food may only be rated as good as the best security/thermal in or adjacent to the target polygon.
- Habitats used primarily for security/thermal may only be rated as good as the best food in or adjacent to the target polygon.

Specifically:

- If the FD rating is better than the ST rating, LI is equal to the best ST in all polygons directly adjacent to the target polygon (including any decile of the target polygon) but not exceeding the FD rating of the target polygon.
- If the ST rating is better than the FD rating, LI is equal to the best FD in all polygons directly adjacent to the target polygon (including any decile of the target polygon) but not exceeding the ST rating of the target polygon.

Table 27. Elk food and security/thermal habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score			
			FD-G	ST-G	FD-W	ST-W
1. BEC Unit	**CAR**	BWBSdk1	2	2	3	3
		ESSFmv4	2	3	5	5
		SWBmk1	2	3	5	5
		ESSFmvp4	2	4	5	5
		SWBmks1	2	4	5	5
		AT	3	5	5	5
	MIR	ESSFmv4	2	2	2	2
		ESSFmvp4	2	4	5	5
		AT	3	5	5	5
	EMR	SWBmk	2	2	2	2
		SWBmks	2	4	5	5
		AT	2	5	5	5
	WMR	BWBSdk1	2	2	3	3
		ESSFmv4	2	2	5	5
		SWBmk1	2	3	5	5
		ESSFmvp4	2	4	5	5
		SWBmks1	2	4	5	5
		AT	3	5	5	5
2a. Site Series (SMR)		Xeric	2	2	2	2
		Subxeric	1	1	1	1
		Submesic	0	0	0	0
		Mesic	0	0	0	0
		Subhygric	0	0	0	0
		Hygric	1	1	1	1
		Subhydric	2	2	2	2
		Hydric	3	3	3	3
2b. Site Series (SNR)		Very poor- poor	1	1	1	1
		Medium-very rich	0	0	0	0
3. Site Modifier		Cool aspect (k)	0	0	1	1
3. Structural Stage		Sparse (1a)	5	5	5	5
		Bryoid (1b)	5	5	5	5
		Herb (2)	0	5	0	5
		Low shrub (3a)	0	5	0	5
		Tall shrub (3b)	2	3	2	4
		Pole/sapling (4)	4	2	4	4
		Young forest (5)	4	1	4	2
		Mature forest (6)	3	0	2	0
		Old forest (7)	3	0	2	0
4. Stand Composition		Broadleaf	0	0	0	3
		Mixed	0	0	0	1

Table 28. Polygon-specific food and security/thermal ratings adjustments for elk.

Topic	Description
A. Terrain surface expression	Polygons lacking forest cover (structural stages 1a, 1b, 2, 3a and 3b) are rated up 2 ST for growing and winter if the surface expression is ridged (r), undulating (u) or hummocky (h).

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3.8 Woodland Caribou (*Rangifer tarandus caribou*)

SPECIES NAME: Woodland caribou
SCIENTIFIC NAME: *Rangifer tarandus caribou*
SPECIES CODE: M-RATA
STATUS: Northern ecotype is not-listed by MELP (1997); Vulnerable (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

Woodland caribou (*Rangifer tarandus caribou*) are associated with the boreal forest region of Canada. They are distributed across the northern portion of British Columbia and extends as far south as Tweedsmuir Provincial Park and the southern Kootenays (Nagorsen, 1990). Mainland populations have been reduced since historical times and small relic herds exist at the southern periphery of its range in the province (Stevenson and Hatler, 1985)

Provincial Benchmark

Ecoprovince: Northern Boreal Mountains
Ecosection: Stikine Plateau (STP)
Biogeoclimatic zone: SWBun/AT in winter and AT in growing
Broad Ecosystem Units: LP/6 – Lodgepole Pine/AG – Alpine Grassland in winter and AM - Alpine Meadow in growing

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains.
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR), Missinchinka Ranges (MIR).
Biogeoclimatic zone: BWBSdk1, SWBmk1, SWBmks1, ESSFmv4, ESSFmvp4 and AT.
Elevational range: Valley bottom to alpine.

Within the Mackenzie TEM Study Area, there are three caribou management areas that encompass distinct caribou populations.

Akie/Ospika: This population is located in the Akie, Pesika and Ospika river drainages on the east side of the Rocky Mountain Trench. This area also includes the Finlay River valley bottom as far south as the Ingenika Arm. Wood (1994) found approximately 200 caribou in this area in winter 1994.

Upper Finlay: The western portion of the Study Area, primarily in the Russel Range, is contained in the Upper Finlay caribou management area. In a March 1993 winter survey, 26 caribou were found in the Russel Range (Wood, pers. comm.).

Chase/Sustut: The south-western portion of the Study Area, located in the Butler Range south of the Ingenika Arm, lies within the Chase/Sustut management area. Wood (1996) found 396 caribou in a winter 1993 survey of alpine winter areas giving a population estimate of 690 ± 202 individuals.

ECOLOGY AND HABITAT REQUIREMENTS

Caribou in British Columbia belong to the woodland subspecies (*Rangifer tarandus caribou*), but they can be further divided into two different ecotypes, mountain ecotype and northern ecotype (Stevenson and Hatler, 1985). Mountain caribou are found in southeastern BC and spend much of the year at high elevations in subalpine forest and alpine habitats. Deep snow prevents them from cratering for terrestrial forage in winter so they rely primarily on arboreal lichens for winter food. Northern Caribou are found in the northern and west-central areas of the province. They generally inhabit mountainous areas in summer, and use low elevation pine forests or windswept alpine areas during winter (Wood, 1996). The low snow depths in those habitats allow them to crater for terrestrial lichens (Seip and Cichowski, 1996). In the Mackenzie TEM Study Area, all caribou are the northern ecotype although a portion of their winter diet may include arboreal lichens (Wood, 1996).

Caribou habitat selection is largely a function of (1) food availability in relation to snow depth and (2) predator avoidance (Bergerud *et al.*, 1984; Bergerud, 1992). Both of these factors generally result in seasonal elevational migratory patterns. Because of the seasonal and annual variability of climate (particularly snow depth) and regional patterns of predator density, multiple habitat types may be occupied and vary from year to year.

Northern caribou habitat use is described in four separate seasons: early-winter, late winter, spring and summer/fall. Their movements follow the general elevational pattern of low/mid-elevation in early-winter, high elevation in late-winter, low elevation in spring and high elevation in summer/fall.

Differences exist among the three known caribou populations present in the study area. Habitat requirement that are shared among all of the populations are described first followed by a population-specific description.

In early-winter, caribou diet is primarily terrestrial lichen, arboreal lichen and conifers (Wood, 1996). In late-winter, they generally move to wind-swept, high-elevation slopes. Wood (1994) reports that all caribou found during a winter ungulate survey of the Muskwa Range were on windswept south or west facing slopes. Diet during late-winter is composed of terrestrial and arboreal lichens, mosses, grasses, shrubs and forbs (Wood, 1996).

In spring (April/May), caribou move from high elevation winter ranges to lower elevation habitat, primarily lodgepole pine and lodgepole pine-white spruce dominated stands (Wood, 1996). In early spring, caribou are seeking new green vegetation in bogs, riparian areas, and open meadows (Hatler 1986). Use of habitats such as south-facing deciduous hillsides, aspen

stands and meadows that become snow-free earlier than heavily timbered areas is common (Wood, 1994).

Summer range is primarily upper elevation Engelman spruce/subalpine fir forests and sub-alpine/alpine areas. Females often ascend to summer ranges for calving before males. In Jasper, summer northern caribou diet is composed of forbs, shrubs and graminoids and continues to include terrestrial lichens. Rutting occurs in the fall and rutting areas are usually in or close to summer habitats (Wood, 1994; Sentar, 1994).

Akie/Ospika

- This population probably uses low elevation pine stand in the Finlay and Akie valley bottoms in **early-winter** (Wood, pers. comm.)**.**
- In **late-winter**, caribou in this area are using high-elevation windswept areas. However, during low snowfall years, they may also remain in low elevation pine forests.
- Wood (1994) found all caribou in high-elevation windswept areas in **late-winter** which was a high snowfall year.
- Terry (1998) found caribou remaining in low elevation pine forests throughout the **winter**.
- Both types of winter habitat are important, it just depends on snow depths.
- Anecdotal reports from Tsay Keh natives suggest that caribou use low elevation pine flats in the Finlay River valley in **winter** (Wood, pers. comm.).

Upper Finlay

- Wood (pers. comm.) reports caribou only in the north end of this management area, outside of the Mackenzie TEM Study Area.

Chase/Sustut

- In **early-winter** (November to January), the majority of radio-collared Chase/Sustut caribou were found in high elevation spruce/fir and low elevation pine/spruce forests.
- In **late-winter** (February to March), nearly all caribou were in alpine/subalpine habitat during a high snowfall year. In a low snowfall year, caribou were found to use both alpine/subalpine and low elevation forests.
- Recent data suggests that the Chase herd generally use mid-elevation and subalpine in **late-winter** (Wood, pers.comm.)
- Wood (1996) concludes that caribou in this area prefer forested areas in winter but are forced onto windswept alpine ridgetops by deep snow.
- 60% of collared caribou were found in low-elevation lodgepole pine and lodgepole pine/white spruce forests in **spring**. Use of habitats that become snow-free earlier is common.
- During calving in late May/early June, all collared females were in upper elevation spruce/fir forests or alpine/subalpine areas. All collared caribou spent the **summer** in these habitats as well**.**

Lichen availability is critical to evaluating mountain caribou habitat however, predicting lichen productivity is difficult. Highest densities are associated with mature forests as lichen is very slow growing. The most suitable growing sites tend to be drier, with low nutrient availability and where productivity of other plants is low (Coxson *et al.*, 1998; Sentar, 1994; Seip, 1996). Coxson *et al.* (1998) also reports higher terrestrial lichen cover on crest and upper slopes of the landscape. Other factors which influence the distribution and abundance of terrestrial lichen are the severity of initial perturbation (e.g. fire), and site conditions.

Wood (1996) reports average caribou density in the Omineca mountains at 0.056 caribou/km^2. Seasonal movements can be considerable; up to 100 km.

Caribou require extensive areas of mature coniferous forest for cover and lichen production. Fire and forest harvesting remove these essential forests. Caribou avoid recently burned areas which affect their movements and fragments their range (Nietfeld *et al.* 1985). They may continue to use burned areas, feeding on lichens in unburned patches, for about five years until fire-killed trees fall and obstruct movement.

Predation, primarily by wolves, can have a severe impact on caribou recruitment. Caribou possess the lowest productivity of the deer family and therefore are slow to recover from population declines (Nietfeld *et al.* 1985). Seip and Cichowski (1996) conclude that the density of caribou populations in BC appears to be related to their ability to become spatially separated from their predators. Further, the abundance of wolves is a function of the availability of its other prey, particularly moose. Therefore, by avoiding habitats that support alternate prey, caribou reduce their exposure to predators.
Wood (1996) suspected that mortalities of radio-collared caribou in the Omineca Mountains were primarily from wolves. In the Mackenzie TEM Study Area, low moose densities (and thus low wolf densities) would be expected in continuos forest cover containing low shrub cover that provide poor moose food and in high elevation alpine and parkland habitats.

LIFE REQUISITES/SEASONAL USE PATTERNS

Caribou life requisites are divided into food, security and reproduction (Table 29).

Table 29. Mountain caribou seasonal life requisites

Rank	Life Requisite	Season	Months
1.	Food	Early-winter	October-December
2.	Food	Late-winter	January-May
3.	Food	Spring	June
4.	Food	Summer/Fall	July-September
5.	Security	All	All
6.	Reproduction	Summer/Fall	July-September

Food

Suitable feeding habitat is an important determinant of caribou distribution and underlies much of their seasonal movements. In early-winter, low elevation sites with an abundance of terrestrial lichen are optimal. Sites with the greatest densities of lichen are dry, mature forests, with low nutrient availability and where productivity of other plants is low. In late-winter, wind-swept south and west facing slopes provide the greatest access to terrestrial lichen in addition to arboreal lichens, grasses, forbs and mosses. In spring, low elevation moist sites, such as bogs, riparian areas, and open meadows, have the earliest green vegetation. Use of south-facing deciduous slopes, aspen stands and meadows that become snow-free earlier than heavily timbered areas is also common. In summer, caribou feed on terrestrial lichen, forbs, shrubs and graminoids in sub-alpine and alpine habitats.

Security

Security from predators is provided primarily by avoidance– habitats that have low wolf density have optimal security. These are areas that have low alternate prey densities, specifically moose, especially in early summer during calving. These areas are at high elevations and at low elevations in forest stands with continuous forest cover. Habitat for security is not rated in this model and is included here only for completeness.

Reproduction

Calving takes place in early summer usually at high elevation in subalpine or parkland habitats. Rutting occurs in the fall within normal summer/fall ranges. Habitat for reproduction is not rated in this model and is included here only for completeness.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between caribou habitat use and TEM ecosystem and terrain attributes are described in Table 30.

Table 30. Caribou habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Caribou in the CAR belong to the Upper Finlay and Chase/Sustut populations described above. Caribou in the EMR belong to the Akie/Pesika herd. Habitat use and caribou density is therefore different between these two Ecosections and this will be differentiated in the following sections. Based on overview capability mapping for the NE region of BC (Habitat Inventory Section, 1994) and BC Environment (1998), the WMR, EMR and MIR provide up to moderately high caribou habitat (corresponding to a rating of 2).The CAR provides up to moderate caribou habitat (corresponding to a rating of 3).
Biogeoclimatic Zone	Northern caribou movements follow the general elevational pattern of low to mid-elevation in early-winter, high elevation in late-winter, low elevation in spring and high elevation in summer/fall. This pattern is dependent on both snow depth and herd. In general, caribou in the CAR caribou utilise mid-elevation forests for than those in the WMR during winter. Spring and summer habitat is assumed to be the same. CAR: • In early-winter, use low elevation pine/spruce (BWBSmw2) and mid-elevation spruce-fir (ESSFmv4 and SWBmk1). • In late-winter, use mid elevation forests (ESSFmv4, SWBmk1) and subalpine/alpine (SWBmks1, ESSFmvp4 and AT), especially when snow is deep. • In spring, found in low elevation forests (BWBSmw2). • Spend summers in upper elevation ESSFmv4, ESSFmvp4 and AT. WMR/EMR/MIR: • In early-winter, primarily use low elevation pine stands (BWBSmw2). • In late-winter, use low elevation pine stands (BWBSmw2) if snow depth is low, otherwise use windswept areas of ESSFmvp4 SWBmks1 and AT. • In spring, found in low elevation forests (BWBSmw2). • Spend summers in upper elevation ESSFmv4, ESSFmvp4 and AT.
Site Series	Moister site series (sub-mesic to sub-hygric) provide better spring and summer/fall forage than drier sites and drier, less-productive sites have a greater probability of high terrestrial lichen densities which provide better winter habitat (Sentar, 1994; Seip, 1996).
Structural Stage	In winter, northern ecotype caribou are found in habitats with high terrestrial lichen. Since lichen is very slow growing, mature forests will have the greatest cumulative lichen densities. The primary structural stages used in early-winter are young forest (5) to old forest (07). In late-winter, herbaceous (2) and sparse/bryoid (1) stages will also be use on wind-blown slopes. In spring, northern caribou seek out early-greening plants and will utilise herb and low shrub stages in addition to mature and old forest. In summer, caribou may be found in herbaceous and shrub stages and in mature and old-forest. Tall shrub (3b), pole/sapling (04) and young forest provide low-level feeding habitat dusting all seasons.
Site Modifier	Wood (1994) found higher use of south aspects in late-winter. Therefore, warm aspects will be rated higher than cool aspects in this season.
Exposure	Northern caribou that use high elevation habitat require exposed, wind-swept areas to access forage. Non-vegetated/sparse and herb structural stages in the SWBmk, SWBmkp and AT would have the greatest likelihood of having windblown, snow-free surfaces.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 6-class rating scheme is used rate habitat suitability for food (FD) in four seasons: early-winter (EW), late-winter (LW), spring (P) and summer/fall (S). Food ratings were assigned to polygons using the ratings table. As described above, caribou habitat use varies depending on winter snow depths. This model shows habitat for both normal and high snowfall years.

Food (FD) Habitat Use Assumptions

The ratings table assigns a suitability rating for FD to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between caribou life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 3.8.2). For example, an optimal structural stage for food has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 4, which would result in a maximum rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Food (FD) Habitat Adjustments

Adjustments are used to modify the ratings in order to account for caribou habitat requirements that are not inherent features of the ecosystem unit.

- Cool aspects (285-135^{o}) are rated down one for FD in late-winter.

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Table 31. Caribou food habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score			
			FD-WE	FD-WL	FD-P	FD-S
1. BEC Unit	CAR	BWBSdk1	2	3	2	4
		ESSFmv4	2	2	3	3
		SWBmk1	2	2	3	3
		ESSFmvp4	4	2	4	2
		SWBmks1	4	2	4	2
		AT	5	2	5	2
	MIR	ESSFmv4	1	3	2	3
		ESSFmvp4	4	1	1	4
		AT	5	1	1	5
	EMR	SWBmk	1	3	2	3
		SWBmks	4	1	1	4
		AT	5	1	1	5
	WMR	BWBSdk1	1	1	1	4
		ESSFmv4	1	3	3	2
		SWBmk1	1	3	3	2
		ESSFmvp4	4	1	4	1
		SWBmks1	4	1	4	1
		AT	5	1	5	1
2a. Site Series (SMR)		Xeric	0	0	1	1
		Subxeric	0	0	0	0
		Submesic	0	0	0	0
		Mesic	0	0	0	0
		Subhygric	0	0	0	0
		Hygric	0	0	0	1
		Subhydric	1	1	1	2
		Hydric	2	2	2	3
2b. Site Series (SNR)		Very poor- poor	0	0	1	1
		Medium-very rich	0	0	0	0
3. Structural Stage		Sparse (1a)	5	0	5	5
		Bryoid (1b)	5	0	5	5
		Herb (2)	5	0	0	0
		Low shrub (3a)	5	5	0	0
		Tall shrub (3b)	5	5	5	5
		Pole/sapling (4)	5	5	5	5
		Young forest (5)	0	0	0	0
		Mature forest (6)	0	0	0	0
		Old forest (7)	0	0	0	0
4. Stand Composition		Broadleaf	2	2	0	0
		Mixed	1	1	0	0

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3.9 Mountain Goat (*Oreamnos americanus*)

SPECIES NAME: Mountain goat
SCIENTIFIC NAME: *Oreamnos americanus*
SPECIES CODE: M-ORAM
STATUS: Not at risk (MELP, 1997; COSEWIC, 1998)

DISTRIBUTION

Provincial Range

Mountain goats are found throughout the Cordilleran region of western Canada and occupy the mainland portion of the province, except for the central interior (Banfield, 1974; Nagorsen, 1990).

Provincial Benchmark

Ecoprovince: Southern Interior Mountains
Ecoregion: Western Continental Ranges
Ecosection: Southern Park Ranges (SPK)
Biogeoclimatic zone: ESSFdk in winter; AT in growing
Broad Ecosystem Units: SF/6 – White Spruce-Subalpine Fir/RO – Rock in winter; AM – Alpine Meadow in growing

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains.
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, SWBmk1, SWBmks1, ESSFmv4, ESSFmvp4 and AT.
Elevational range: Mid-elevation to alpine.

ECOLOGY AND HABITAT REQUIREMENTS

Mountain goats are associated with mountainous, high elevation terrain although they may be found in a variety of habitats ranging from coastal forests through to subalpine and alpine areas. Two mountain goat ecotypes are generally considered: coastal and interior (Hebert and Turnbull, 1977; Chadwick, 1983). The main differences between these ecotypes appears to be diet and winter habitat use. The feature common to all mountain goat areas is precipitous topography which functions as escape terrain and provides snow shedding capability, especially important in high snowfall areas (Fish and Wildlife Branch, 1979).

Optimum habitat for mountain goats contains feeding areas interspersed with escape terrain. Goats in the interior are predominantly grazers (Herbert and Turnbull, 1977) and their diet includes grasses, sedges, rushes, forbs, shrubs, lichen and conifers (Fish and Wildlife Branch, 1979). Varley (1994), studying in Wyoming and Montana, found most feeding mountain goats used slopes between 16 and 60^{o} and nearly all feeding goats were within 50m of escape terrain. Haynes (1992) also studying in Wyoming, found nearly all goats within 400m of cliffs.

The availability of suitable winter range is generally a limiting factor. Goats will move long distances to low elevation ranges where snow depths are less and forage is accessible; however, they will also winter on high, steep cliffs where wind action is greatest and escape terrain is available. Nietfeld *et al*. (1985) reports that goats in Alberta generally descend to where snow depths are less than 45cm. Adams *et al.* (1980) reports that on Colorado winter ranges, goats preferred areas without persistent or melt-crusted snow where cliffs were interspersed with tundra treeline or with shrubs or sparse coniferous habitats below the treeline. Smith (1977), studying in western Montana, found greatest use of southern exposure, lower elevations and cliff terrain when winter snow depths were greatest. Goats in many areas also find winter forage and thermal protection in open mature forests (MOF and BCE, 1997). Winter ranges are typically south and west-facing slopes (Fish and Wildlife Branch, 1979; Poole and Mowat, 1997). During severe weather, caves, overhanging ledges and the sheltered side of cliffs provide refuge (Soper, 1982).

A survey of the Russell Range in March, 1993 found most mountain goats on south west-facing aspects (Wood, pers. comm.). Of the 211 goats observed, 93% were in the alpine zone.

Summer goat ranges are extensive and only limited by the availability of escape terrain (Phelps *et al.*, 1985). North and east-facing slopes are often preferred as they have the greatest supply of snow and water, providing continuously green, succulent forage (Nietfeld *et al*., 1985; Varley, 1994). Goats will frequently travel to mineral licks (if available) and these may be used extensively in summer and fall after feeding on low sodium forage in spring and early summer (Phelps *et al.*, 1983). In a summer survey of the Russell Range, Watts and Child (1986) found the majority of goats above 1800 m.

Seasonal migrations between summer and winter ranges are not pronounced and movements are often contained within a single, contiguous range. However, goat populations that utilise mineral licks may move long distances through a variety of habitats including closed canopy forest.

Rutting season occurs in November and early December and kids are born in late May or early June. Natal areas are often in the most rugged portion of the goat's range and are located in a sheltered spot, such as a cave or overhang (Fish and Wildlife Branch, 1979).

LIFE REQUISITES/SEASONAL USE PATTERNS

In this model, mountain goat life requisites and divided into security, food, reproduction and living (Table 32).

Table 32. Mountain goat seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Security	All seasons	Year-round
2.	Food	Winter	October-April
3.	Food	Growing	May-September
4.	Reproduction	Growing	May-September
5.	Living	Growing and winter	May-September October-April

Security

Steep slopes provide security (or escape terrain). In Alberta, 50% of goats reported have been on slopes greater than 100% (Nietfeld *et al.*, 1985). Haynes (1992) found that Wyoming goats used terrain greater than 78% as their primary habitat and preferred slopes greater than 100%. Chadwick (1983) found goats on slopes greater than 90% more than seventy percent of the time. Slope requirements greater than 100% are poorly documented however cliffs approaching vertical are known to be used preferentially.

Food

Summer feeding areas are at high elevations and may occur wherever escape cover nearby. Winter feeding areas include wind-swept ridges, steep cliffs and high elevation, open forests.

Reproduction

Both rutting and natal areas occur within a goat's normal territory. Natal areas are often located in the most rugged portion of the territory but is not significantly different from the habitat required at other times of the year. Habitat for reproduction is not rated in this model and is included here only for completeness.

Living

Habitat that provides living contains security and food in close proximity. MOF and BCE (1997) and Haynes (1992) report that goats are rarely more than 400 m from escape terrain where Varley (1994) found most feeding mountain goats within 50m of escape terrain.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between goat habitat use and TEM ecosystem and terrain attributes are described in Table 33.

Table 33. Goat habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Mountain goats occur in all four Ecosections. Greater snow depths in the WMR, EMR and MIR results in poorer goat habitat than the CAR. Habitat in the CAR Ecosection is rated up to 50-75% of the best habitat in the province (moderately high or 2) and habitats in the WMR, EMR and MIR Ecosections are rated up to 25-50% of the best habitat in the province (moderate or 3). These ratings represent maximum year-round ratings for mountain goat and ratings for individual life requisites in particular seasons may be higher.
Biogeoclimatic Zone	Mountain goat habitat occurs in the AT, ESSFmv4, ESSFmvp4, SWBmk1 and SWBmks1. In general, goats are not found in the BWBSdk1 due to the lack of escape terrain at low elevation in the Study Area. However, they may be present in this zone if they are travelling to or are at a mineral lick. Since this zone does not provide significant goat habitat, it is generally rated low. The AT primarily provides habitat in the growing season however, wind-blown south aspect cliffs may also provide suitable winter habitat. The ESSFmvp1 and SWBmks1 provide goat habitat year-round. Goat use in the ESSFmv4 and SWBmk1 is highest in winter when goats may descend to seek out lower snow depths.
Site Series	Soil moisture regimes sub-xeric to sub-hygric provide better feeding habitat than sites that are xeric and sites that are hygric or wetter.
Structural Stage	Goats in the interior are most often found in non-forested habitats. Herbaceous sites provides optimal foraging. Non-vegetated/sparse, shrub/herb and low shrub provide the next best. Tall shrub, pole/sapling and young forest generally provide little feeding habitat with one exception– structural stage 3b in the ESSFmvp4 and SWBmks1 are usually composed of open, often krumholtz forest that provides suitable forage. In winter, Mature and old-growth forest provide moderate feeding in the SWBmk1 and ESSFmv4 and better quality winter feeding in the SWBmks1 and ESSFmvp4. Stages herb to low shrub provide moderate food in winter, however, if they are on steep slopes (see next section), snow depths are reduced and food is therefore more accessible.
Slope	Slopes greater than 100% provide the best escape terrain. Slopes between 80 and 100% provide moderate escape terrain and slopes less than 80% provide little. In winter, steep slopes also provide feeding habitat because snow is easily shed, thus exposing forage. Polygons classified as cliff (CL) provide optimal escape terrain.
Aspect	Winter ranges are typically on south and west-facing slopes. North and east-facing slopes are often preferred in summer as they have the greatest supply of snow and water, providing continuously green, succulent forage. Therefore, warm aspects (135-285°) are rated down one for feeding and security in the growing season cool aspects (285-135°) are rated down one for feeding in winter.
Proximity effects	Areas used for feeding must be adjacent to escape terrain. It is assumed that feeding habitat must be less than 400m from escape terrain. Areas located greater than 400m from escape terrain are not likely to be used.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 6-class rating scheme is used to rate mountain goat habitat for food (FD), security (SH) and living (LI) in growing and winter.

FD ratings are defined in the ratings table. SH ratings are not found in the ratings table because slope is not an inherent feature of the ecosystem units. LI encompasses all of the requirements necessary for survival and is a function of the spatial arrangement of FD and SH in the landscape. The LI ratings are generated using a GIS algorithm.

Food (FD) Habitat Use Assumptions

The ratings table assigns a suitability rating for FD to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between mountain goat life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 35). For example, the optimal structural stage for food (herb) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 4, which would result in a maximum rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Polygon Food Habitat (FD) Use Adjustments

Adjustments are used to modify the ratings in order to account for the species' habitat attributes that are not inherent features of the ecosystem unit (Table 35).

Table 34. Mountain goat food habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score	
			FD-G	FD-W
1. BEC Unit	**CAR**	BWBSdk1	1	1
		ESSFmv4	1	1
		SWBmk1	1	1
		ESSFmvp4	1	1
		SWBmks1	1	1
		AT	1	1
	MIR	ESSFmv4	2	2
		ESSFmvp4	2	2
		AT	2	2
	EMR	SWBmk	2	2
		SWBmks	2	2
		AT	2	2
	WMR	BWBSdk1	2	2
		ESSFmv4	2	2
		SWBmk1	2	2
		ESSFmvp4	2	2
		SWBmks1	2	2
		AT	2	2
2a. Site Series (SMR)		Xeric	1	1
		Subxeric	0	0
		Submesic	0	0
		Mesic	0	0
		Subhygric	0	0
		Hygric	0	0
		Subhydric	1	1
		Hydric	2	2
2b. Site Series (SNR)		Very poor- poor	0	0
		Medium-very rich	0	0
3. Site Modifier		Warm aspect (w)	1	0
		Cool aspect (k)	0	1
4. Structural Stage		Sparse (1a)	0	1
		Bryoid (1b)	0	1
		Herb (2)	0	1
		Low shrub (3a)	0	1
		Tall shrub (3b)	3	2
		Pole/sapling (4)	2 (0)[a]	2 (0)[a]
		Young forest (5)	2	2
		Mature forest (6)	2 (0)[a]	1 (0)[a]
		Old forest (7)	2 (0)[a]	1 (0)[a]
5. Stand Composition		Broadleaf	0	0
		Mixed	0	0

[a] Conditional rating: if zone is ESSFmvp4 or SWBmks1, then down-rating adjustment equals 0.

Table 35. Mountain goat polygon-specific food ratings adjustments.

Topic	Description
A. Slope	Slopes greater than 100% are rated up 1 FD in winter.

Security Habitat (SH) Use Assumptions

Security ratings were applied using site series and terrain surface expression slope classes:

- Polygons classified as cliff (CL) rated 1 SH;
- Polygons classified as rock outcrop (RO) rated 2 SH;
- Slopes 80-100% (surface expression code "s") and structural stage 1-3, rated 4 SH.
- All other surface expression codes) rated 6 SH.

Living (LI) Habitat Use Assumptions

The LI rating is a combination of the FD and SH rating and is generated using a GIS algorithm. Since a given habitat can generally only be as good as the most limiting life requisite, LI is calculated as the lower rating between the polygon FD rating and the best SH rating in all polygons within 400m.

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3.10 Stone Sheep (*Ovis dalli stonei*)

SPECIES NAME: Stone sheep
SCIENTIFIC NAME: *Ovis dalli stonei*
SPECIES CODE: M-OVDS
STATUS: Blue-listed (MELP, 1997); not at risk (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

In BC, Stone sheep are found from the Yukon border to just south of the Peace Arm of Williston Reservoir (Nagorsen, 1990).

Provincial Benchmark

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Canadian Rocky Mountains
Ecosection: Muskwa Foothills (MUF)
Biogeoclimatic zone: SWBmk in winter; AT in growing
Broad Ecosystem Units: BA/1 – Boreal White Spruce-Trembling Aspen/RO – Rock in winter; SM – Subalpine Meadow in growing

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Canadian Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, ESSFmv4, SWBmk1, SWBmks1, ESSFmvp4 and AT
Elevational range: Valley bottom to alpine

ECOLOGY AND HABITAT REQUIREMENTS

The world population of Stone sheep inhabits mountainous areas of northern British Columbia and the southern Yukon (Seip, 1983; MELP, 1978). Populations occur on the Yukon and Stikine plateaus, the Skeena, Cassiar and Omenica Mountains from the Pine River to the Liard River, and the Boundary Ranges of the Coast Mountains (Fish and Wildlife Branch, 1978). Good sheep habitat is described as narrow linear ridges, talus slopes and nearly vertical cliffs interspersed with gently sloping saddles and alpine meadows with abundant vegetation (Seip 1983). They eat primarily grasses and sedges, but also supplement their diet with several kinds of herbs in the summer and woody plants in the winter (Banfield, 1977).

Stone sheep generally have two distinct ranges: summer and winter with corresponding spring and fall migrations (Chapman and Feldhamer, 1982). During summer, they inhabit alpine slopes and plateaus, moving higher with the green-up of succulent grasses and forbs (Scotter and Ulrich, 1995, Seip 1983) and always on or adjacent to precipitous terrain. In a summer survey of the Russel Range, Watts and Child (1986) found almost all sheep above 1800 m.

In winter, snow cover limits the availability of forage and Stone sheep select habitats that have less snow, either at lower elevations or in wind-blown areas. They are known to use lower, drier, southern-facing slopes (Banfield, 1977) however, they commonly use mountain peaks and ridges at elevations up to 2200m, as documented by Seip (1983). They may also move up and utilise the often sparse vegetation of the upper slopes as wind clears the snow off after storm events (Luckhurst, 1973). Seip (1983) found that in the Yedhe, Delano, and Racing River areas, Stone sheep were using mountain peaks and ridges as winter range. These were at elevations between 1500 to 2200 m and the primary characteristic of these areas appeared to be their tendency to be blown free of snow. The average snow depth used by the sheep was 16.5cm and the depth where they ceased digging for food was 32.4 cm (Seip 1983).

Wood (1994) reports Stone sheep using southwest facing ridges in the Pesika drainage (WMR Ecosection) in winter, but suggested their numbers in this area would be low because of the high snow depth. Stone sheep were sighted in the Russel Range (CAR Ecosection) on south facing windblown slopes within the TEM Mackenzie Study Area (unpublished winter ungulate flight, 1997).

Luckhurst (1973) found that the *Elymus – Agropyron* vegetation community provided almost 60 percent of the forage utilised by wintering Stone sheep in the Nevis Creek area. Other important plant communities used in winter were the *Elymus-Festuca*, and *Dryas-Festuca* communities. *Calamagrostis-Hierochloe*, *Betula-Vaccinium vitis-idaea* and *Festuca-Dryas* communities were used most in summer.

Specific requirements for escape terrain are not well documented for Stone sheep. Bighorn sheep (*Ovis canadensis*) escape terrain has been much better characterised and we assume that escape terrain requirements are similar between the two species. Van Dyke *et al.*.(1983), in a review of California bighorn sheep (*O. canadensis californiana*) escape areas, reports that steep broken cliffs with traversible terraces are most desirable; where steep cliffs are lacking, steep slopes and talus are used. Escape terrain must be higher than 8 m and larger than 0.16 ha but must be larger than 2 ha to suffice as lambing habitat. Van Dyke *et al.* (1983) also reports that optimal bighorn foraging habitat lies within 1 km of suitable escape terrain and few bighorns forage more than 1.6 km from escape terrain. Smith *et al.* (1991) report more restrictive distances: generally only 300 m but as much as 500 m if escape terrain is available on more than one side.

Although cliffs contain only sparse vegetation, they may be important for feeding in winter as the steep slopes readily shed snow and are often warmer, thus providing easier access to forage (Van Dyke *et al.*, 1983).

The breeding season extends from about mid-November to mid-December, and the gestation last about 175 days, with lambing in May. Pregnant ewes leave the band and go to the most rugged place in there summer range to give birth (Scotter and Ulrich, 1995, Seip 1983, Chapman, and Feldhamer. 1982).

Mineral licks appear to be an important habitat requirement of Stone sheep, and may be a means of replenishing mineral reserves depleted during the winter (Scotter and Ulrich, 1995, Seip 1983). Mineral lick use occurs primarily between April to July (Seip 1983). Stone sheep were observed in the Mackenzie study area at the Pesika mineral licks on September 1, 1997 (incidental sighting, 1997).

LIFE REQUISITES/SEASONAL USE PATTERNS

Stone sheep life requisites are divided into security, food, reproduction, migration and living (Table 36).

Table 36. Stone sheep seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Security	All seasons	Year-round
2.	Food	Winter	October-May
3.	Food	Growing	June-September
4.	Reproduction	Growing	June-September
5.	Migration	Growing	June-September
6.	Living	Year-round	Year-round

Security

In general, Stone sheep are restricted to semi-open, precipitous terrain with rocky slopes, ridges, cliffs or rugged canyons. Specific Stone sheep security requirements must be inferred from those requirements documented for California and Rocky Mountain bighorn sheep. We assume that optimal security habitat is provided by slopes greater than 60° (133%), moderately high security provided by slopes between 40 and 60° (90-133%), moderately low between 30 and 40° (67-90%) and no security provided in polygons with slopes less than 30° (67%).

Food

Stone sheep range in the growing season has been characterized by Seip (1983) as natural subalpine clearings including streamsides, rockslides, talus slopes and avalanche chutes. Natural clearings in the Spruce-Willow-Birch (SWB) zone and high alpine peaks and ridges were also being used by Stone sheep in the Mackenzie TEM Study Area. Seip (1983) observed that Stone sheep made extensive use of burned areas in the spring and fall.

Reproduction

Stone sheep lambing habitat is usually part of their winter range or as an intermediate between winter and summer range (Chapman and Feldhamer, 1982). Preferred lambing range is in the most precipitous, inaccessible cliffs near forage, and generally has a dry, southern exposure (reviewed by Chapman and Feldhamer, 1982; Seip, 1983; Scotter and Ulrich, 1995). Habitat for reproduction is not rated in this model.

Living

Habitat that provides general living requirements are food habitats in close proximity to habitat that provides security. We assume that optimal foraging habitat occurs within 300 m of adequate security, moderate foraging can be provided in areas between 300 and 500 m, low foraging provided by habitat between 500 and 1000 m and no forage opportunities occur more than 1.0 km from security habitat.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between Stone sheep habitat use and TEM ecosystem and terrain attributes are described in Table 37.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A 6-class rating scheme is used to rate Stone sheep habitat for food (FD), security (SH) and living (LI) in growing (G) and winter (W).

This model considers only three of many possible life requisites that could be considered for Stone sheep. However, we assume that food, security and living represent the most important and if these are satisfied, other life requisites are also satisfied.

Living encompasses all of the requirements necessary for survival and is a function of the spatial arrangement of FD and SH in the landscape.

Food (FD) Habitat Use Assumptions

The ratings table assigns a suitability rating for FD to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between Stone sheep life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 38). For example, the optimal structural stage for food (herbaceous) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as pole-sapling) has a degrading score of 4, which would result in a maximum rating of 5 on a scale of 1 to 6. By summing the degrading scores over all of the

ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Polygon Food (FD) Habitat Use Adjustments

Adjustments are used to modify the ratings in order to account for Stone sheep habitat attributes that are not inherent features of the ecosystem unit. There is one adjustment:

- Cool aspects (285-135°) rated down 1for FD in winter.

Table 37. Stone sheep habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Stone sheep occur in all four Ecosections. Greater snow depths in the WMR, EMR and MIR results in generally poorer Stone sheep habitat than the CAR where less snow, shorter more rounded mountains and a greater number of south facing ridges provides more productive winter habitat. Habitat in the CAR Ecosection is rated up to 50-75% of the best habitat in the province (moderately high or 2) and habitats in the WMR Ecosection is rated up to 25-50% of the best habitat in the province (moderate or 3). These ratings represent maximum year-round suitabilities for Stone sheep and ratings for individual life requisites in particular seasons may be higher.
Biogeoclimatic Zone	In the Mackenzie TEM Study Area, Stone sheep habitat occurs in the AT, ESSFmv4, ESSFmvp4, SWBmk1 and SWBmks1. Stone sheep may also be present in the BWBSdk1 if they are travelling to or are at a mineral lick. However, since this zone does not provide significant Stone sheep habitat, it is generally rated low. The AT primarily provides habitat in the growing season however, wind-blown cliffs and ridges with south and west facing aspects may also provide suitable winter habitat. The ESSFmvp1 and SWBmks1 provide sheep habitat year-round. Sheep use in the ESSFmvp4 and SWBmks1 is highest in winter when sheep may descend to seek out lower snow depths on wind blown south or west facing ridges.
Site Series	Mesic and moister site series (soil moisture regimes sub-mesic to sub-hygric) provide better feeding habitat than drier site series.
Structural Stage	Stone sheep are most often found in areas consisting of few trees, some low-growing shrubs and either natural or burned grasslands. Structural stage 02 (herb) provides optimal foraging and structural stages 01 (non-vegetated/sparse), 03 (shrub/herb) and 3a (low shrub) provide the next best. Structural stages 3b (tall shrub), 04 (pole/sapling) and 05 (young forest) generally provide little feeding habitat with one exception– structural stage 3b in the ESSFmvp4 and SWBmks1 are usually composed of open, often krumholtz forest that provides suitable forage. In winter, structural stages 06 and 07 (mature forest and old-growth forest respectively) provide low-level feeding in the SWBmk1 and ESSFmv4 and better quality winter feeding in the SWBmks1 and ESSFmvp4.
Slope	We assume that optimal security habitat is provided by terrain units with surface expressions moderately steep (60-78%) and steep (>78%). Moderate security is provided by terrain units with the surface expression moderate slope (35-60%). No security is provided by slopes less than 36%.
Aspect	Warm aspects provide better winter habitat for Stone sheep. Therefore, cool aspects (285-135°) are rated down for use in winter.
Proximity effects	Areas used for feeding must be adjacent to escape terrain. We assume that feeding habitat must occur within 500 m of escape terrain.

Table 38. Stone sheep food habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score	
			FD-G	FD-W
1. BEC Unit	**CAR**	BWBSdk1	4	4
		ESSFmv4	2	2
		SWBmk1	2	2
		ESSFmvp4	1	1
		SWBmks1	1	1
		AT	1	1
	MIR	ESSFmv4	3	3
		ESSFmvp4	2	2
		AT	2	2
	EMR	SWBmk	3	3
		SWBmks	2	2
		AT	2	2
	WMR	BWBSdk1	4	4
		ESSFmv4	3	3
		SWBmk1	3	3
		ESSFmvp4	2	2
		SWBmks1	2	2
		AT	2	2
2a. Site Series (SMR)		Xeric	1	1
		Subxeric	0	0
		Submesic	0	0
		Mesic	0	0
		Subhygric	0	0
		Hygric	0	0
		Subhydric	1	1
		Hydric	2	2
2b. Site Series (SNR)		Very poor- poor	0	0
		Medium-very rich	0	0
3. Structural Stage		Sparse (1a)	0	1
		Bryoid (1b)	0	1
		Herb (2)	0	1
		Low shrub (3a)	0	1
		Tall shrub (3b)	3	2
		Pole/sapling (4)	3 (0)[a]	2 (0)[a]
		Young forest (5)	3	3
		Mature forest (6)	3 (0)[a]	1 (0)[a]
		Old forest (7)	3 (0)[a]	1 (0)[a]
4. Stand Composition		Broadleaf	0	0
		Mixed	0	0

[a] Conditional rating: if zone is ESSFmvp4 or SWBmks1, then down-rating adjustment equals 0.

Security Habitat (SH) Use Assumptions

Security ratings were applied using site series and terrain surface expression slope classes:

- Polygons classified as cliff (CL) rated 1 SH;
- Polygons classified as rock outcrop (RO) rated 2 SH;
- Slopes 80-100% (surface expression code "s") and structural stage 1-3, rated 3 SH.
- Moderately steep ("k", 60-78% slope) and structural stage 1-3, rated 4 SH;
- All other surface expression codes) rated 6 SH.

Living (LI) Habitat Use Assumptions

The LI rating is a combination of the FD and SH rating and is generated using a GIS algorithm. Since a given habitat can generally only be as good as the most limiting life requisite, LI is calculated as the lower rating between the polygon FD rating and the best SH rating within 500m.

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3.11 Northern Goshawk (*Accipter gentilis*)

SPECIES NAME: Northern Goshawk
SCIENTIFIC NAME *Accipter gentilis*
SPECIES CODE: B-NOGO
STATUS: Yellow listed (MELP, 1997); not at risk (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

The Northern Goshawk is widely distributed throughout the province, being least numerous along the coast, and most abundant in the northern interior (Campbell et al., 1997). It is found throughout the province including Vancouver Island and the Queen Charlottes. Two sub species of Goshawk occur in British Columbia *Accipiter gentilis atricapillus* generally distributed throughout the province, axcept on Vancouver Island and the Queen Charlotte Islands where *A. g. laingi* is found. The latter race is probably resident (Taverner, 1940).

Provincial Benchmark

Ecoprovince: Not established
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, ESSFmv4, ESSFmvp4, SWBmk1 and SWBmks1, AT
Elevational range: Valley bottom to alpine

ECOLOGY AND HABITAT REQUIREMENTS

The Northern Goshawk is a large forest raptor, one of three accipiter species of hawks occupying boreal and temperate forests throughout the Holarctic (Squires and Reynolds, 1997). Goshawks are described as a bird of mixed, open, and dense forests and frequent a wide variety of habitats from sea level to 2,290m elevation in BC (Campbell *et al*., 1990). They have been reported in almost every forest type in British Columbia.

Goshawks prey upon a variety of mammals and birds, including squirrels, hares, grouse, corvids, woodpeckers and large passerines (Campbell *et al*., 1990, Squires and Reynolds, 1997). They

select foraging sites where structural characteristics favour their foraging strategies (Beier and Drennan, 1997). Palmer (1988) reports that historically Goshawks have fluctuated in numbers with the snowshoe hares and ruffed grouse, thereby indicating a dependence to some degree on the two for survival and their presence for foraging in similar habitats.

Goshawks hunt in mature to old (60-100 years) forest with patches of younger forest (10-20 yrs.) interspersed. They hunt very effectively within and below the forest canopy (Palmer, 1988). Breir and Drennan (1997) found that Goshawks selected foraging sites that had high canopy closure, good tree density, and trees greater than 41 cm dbh (diameter at breast height). Hunting domains in general include boreal areas with scattered patches of willow or alder, alpine parkland communities, some farmland, but generally near scattered trees or brushy areas and preferably woodland. Plucking perches are used by Goshawk and may consist of old stumps from tip-ups, an old nest or a limb, but preferably a bent-over tree or sapling (Palmer, 1988).

Some of the most productive habitats for Goshawks are ecotones (edges). For example, areas with changes in forest composition, as where conifers and brush meet, burned areas, or where a watercourse or a bog interrupts the mature forest pattern. Openings in the forest may increase nest access, serve as travel corridors (Erickson, 1987; Speiser and Bosakowski, 1987), or reduce flight barriers to fledglings for hunting (Hall, 1984). Goshawk also hunt along creeks, rivers, lakeshores, lagoons, seacoasts, islands, and estuaries and their associated habitats (Campbell *et al.*, 1990).

Goshawks nest in dense mature stands of a variety of forest types, although more often in coniferous stands (Campbell *et al*., 1990; Bosakowski, 1997). Their nest site selection is related more to forest structure than forest type. Preferences for mature and old forests is related to their requirement for a tree sufficiently large to support a stick nest 90cm in diameter and 36cm in depth. Nests are located on trees which develop good sturdy crotches such as aspens among spruces, alders among firs and so on (Beebe, 1974) and these sites are more often located on slopes no greater that 60%. Nest trees in aspen and lodgepole pine were also thought to be preferred because of the lack of branches on the bole of the tree beneath the nest. The lack of lower branches allows for ease of entry into the nest. Squires and Ruggiero (1996) report that on average, Goshawk nests are found in sites with greater than 60% canopy closure. Goshawks also prefer north-facing cooler aspects for nesting (Squires and Reynolds, 1997).

Forest stands containing nests are often small, approximately 10-100 ha (Reynolds *et al.,* 1982; Woodbridge and Detrich, 1994) and territories may contain 1-5 alternative nest areas. In Oregon, nests are frequently found near breaks in the canopy produced by logging trails, downed trees, or in openings in under story conifers from over story shading (Reynolds *et al.,* 1982).

Goshawks are very territorial against other raptors, including other Goshawks, during nesting (Beebe, 1974, Kosterzewa, 1991). The post fledgling area may represent a defended portion of territory (Reynolds *et al.,* 1992), which includes approximately 170 ha surrounding the nest (Kennedy *et al.*, 1994). Average territory sizes of Goshawks in Alaska include were 3,982 ha for males and 2,737 ha for females but were very variable (Titus *et al.,* 1994).

Goshawk migrational patterns in North America are poorly understood. They are year round residents when prey is abundant and when weather is favourable. There are sometimes large movements of Goshawks south following cyclical changes in prey, approximately every 10 years (Campbell *et al*., 1990; Squires and Reynolds, 1997).

Goshawks may experience short elevational movements in the winter, moving from higher elevation, dense forest habitats to lower, more open habitat types (Squires and Reynolds, 1997). Mountain ridges and meadows are used during migrational movement. Their winter habitat selection is more dependent on prey abundance than on the presence of woodland habitat, however, Goshawks preying on squirrels, snowshoe hare and grouse will remain in mature forests (Squires and Reynolds, 1997).

Clearcutting has a negative impact on Goshawks and logging activities around nest sites can cause abandonment of eggs or juveniles (Squires and Reynolds, 1997).

LIFE REQUISITES/SEASONAL USE PATTERNS

Goshawk life requisites are divided into food, security, reproduction and living (Table 39).

Table 39. Goshawk seasonal life requisites

Rank	Life Requisite	Season	Months
1.	Food	All	All months
2.	Security	All	All months
3.	Reproduction	Growing	June to September
4.	Living	All	All months

Food

Goshawks hunt in mature to old forest with patches of younger (10-20 yrs.) forest interspersed. Some of the most productive, diverse habitats are ecotones (edges); Goshawks can often be found hunting along the edges of wetlands and riparian edges.

Security

Security provides access to nest sites, roosting sites and hunting areas. During the reproductive season, habitats that provide good security provide optimal reproductive habitat. Favourable security habitat is forest with a closed canopy (>60%) and room to fly beneath the canopy and between trees. This corresponds to between 500-800 stems/ha (reviewed by Bosakowski 1997) and occurs most commonly in mature and old coniferous forests.

Reproduction

Reproductive areas are composed of habitat that provides good security (which is assumed to contain suitably large trees to support a nest) and habitat that provides food within 2.5 km (given

an average home range size of 2400 ha). Good reproductive habitat is also north-facing and within 2.5 km of water.

Living

Living habitat includes both food and security requirements, both during the winter and for non-breeding individuals, during the growing season.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between Goshawk habitat use and TEM ecosystem and terrain attributes are described in Table 40.

Table 40. Goshawk habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	Goshawks are known to occur in all four Ecosections although at relatively low densities. It is estimated that the Mackenzie TEM study area provides up to 25% of the best Goshawk habitat in the province, corresponding to a rating of 4 (low).
Biogeoclimatic Zone	In the Mackenzie TEM Study Area, Goshawk habitat potentially occurs in all of the subzones. The BWBSdk1, ESSFmv4 and SWBmk1 provide the best year-round habitat. Because Goshawk are dependent on good forest cover for security, the ESSFmvp4 and the SWBmks1 are generally rated low for security although these areas may still provide food. In the Muskwa Range, a Goshawk was observed in the SWB parkland zone in winter.
Site Series	Mesic and moister site series (mesic to hydric) provide better hunting habitat than drier site series. In addition, it is assumed that submesic to subhydric sites have the highest canopy closure and are therefore rated higher for security.
Structural Stage	Structural stage 06 (mature forest) and 07 (old growth forest) generally provide the best security and thus the best reproduction habitat. Structural stages 3b (tall shrub), 04 (pole/sapling) and 05 (young forest) provide food foraging habitat when interspersed with structural stages 06 and 07. In winter, all structural stages can be used providing they are interspersed with structural stages 06 and 07.
Aspect	Cool aspects (285-135°) provide better reproductive habitat than warm aspects (135-285°)
Water	Many researchers report that Goshawk nests are usually found near small streams or ponds (reviewed by Squires and Reynolds 1997). Therefore, given the average size of a Goshawk home range (2400 ha), habitats are rated down for reproduction if there is no water within 2.5 km.
Canopy Closure	Habitats with less than 60% canopy closure provide poorer security. The effect of canopy closure has been incorporated into the site series assumptions described above.
Disturbance	Human disturbance negatively effects Goshawks during their reproductive period. Therefore, polygons within 100 m of a road or active logging will be rated down for reproduction. The areas that are cleared around the camps and towns create more edges and therefore more potential hunting habitat, but overall make very poor reproductive habitat.

HABITAT RATINGS

Rating Scheme/ Modelling Theme

A six-class rating scheme is used to rate Goshawk habitat for food (FD), security (SH) and living (LI) in all seasons (A) and reproduction (RP) in the growing season.

This model predicts habitat suitability for breeding and non-breeding Goshawks. Living (LI) encompasses all of the non-breeding habitat requirements necessary for survival and is a combination of the FD and SH ratings. This applies year-round for juveniles and from September to May for breeding adults.

Food (FD) and Security (SH) Habitat Assumptions

The ratings table assigns a suitability rating for FD and SH to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between Goshawk life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 41). For example, the optimal structural stage for food (low shrub) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as sparse) has a degrading score of -2, which would result in a maximum rating of 3 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Food (FD) and Security (SH) Ratings Adjustments

Adjustments are used to modify the ratings in order to account for Goshawk habitat attributes that are not inherent features of the ecosystem unit. There is one adjustment for Goshawk:

Reproduction (RP) Habitat Assumptions

Reproductive habitat is defined as those area with high rated security (4) and have food within 2.5 km. There are two adjustment to reproductive ratings (Table 42).

Table 41. Northern Goshawk food habitat use assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score	
			FD-G	SH-G
2. BEC Unit	**CAR**	BWBSdk1	3	3
		ESSFmv4	3	3
		SWBmk1	3	3
		ESSFmvp4	3	3
		SWBmks1	3	3
		AT	4	5
	MIR	ESSFmv4	3	3
		ESSFmvp4	3	3
		AT	4	5
	EMR	SWBmk	3	3
		SWBmks	3	3
		AT	4	5
	WMR	BWBSdk1	3	3
		ESSFmv4	3	3
		SWBmk1	3	3
		ESSFmvp4	3	3
		SWBmks1	3	3
		AT	4	5
3a. Site Series (SMR)		Xeric	1	1
		Subxeric	0	0
		Submesic	0	0
		Mesic	0	0
		Subhygric	0	0
		Hygric	0	1
		Subhydric	1	2
		Hydric	2	2
3b. Site Series (SNR)		Very poor- poor	1	1
		Medium-very rich	0	0
4. Structural Stage		Sparse (1a)	1	2
		Bryoid (1b)	1	2
		Herb (2)	1	2
		Low shrub (3a)	0	2
		Tall shrub (3b)	0	1
		Pole/sapling (4)	1	1
		Young forest (5)	1	1
		Mature forest (6)	0	0
		Old forest (7)	0	0
5. Stand Composition		Broadleaf	0	0
		Mixed	0	0

Table 42. Goshawk polygon-specific reproduction ratings adjustments.

Topic	Description
A. Proximity to water	Polygons that are more than 2.5 km from water are rated down 1 RP.

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3.12 Peregrine Falcon (*Falco peregrinus anatum*)

SPECIES NAME: Peregrine Falcon
SCIENTIFIC NAME: *Falco peregrinus anatum*
SPECIES CODE: B-PEFA
STATUS: Red-listed (MELP, 1997); Endangered (COSEWIC, 1998)

DISTRIBUTION:

In North America, peregrine falcons breed from north of the tree-line in Alaska and Canada south to central Canada, and along the Pacific coast and in the western cordillera south to Mexico. They winter from the northern United States, coastal and south western British Columbia and southern Ontario southward (Campbell *et al*., 1990).

Provincial Range

There are two subspecies that occur within British Columbia: Peale's (*Falco peregrinus pealei*) and American (*Falco peregrine anatum*). Peale's peregrine are widespread coastal breeders, essentially residents on the islands and headlands of the Pacific coast. The anatum (American) form is a local breeder in northern areas of BC including the south of Alaska. It is a rare resident in the Okanagan valley and the Chilcotin-Caribou region and very rare elsewhere in the interior. It has been identified as a very rare migrant in the east Kootenay region (Campbell *et al.*, 1990).

Provincial Benchmark

Ecoprovince:
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Not officially established but likely the Southern Interior Mountains Ecosection (Campbell *et al*., 1990)

Project Study Area

Ecoregion: Northern Mountains and Plateaus and Northern Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, ESSFmv4, ESSFmvp4, SWBmk1, SWBmks1 and AT
Elevational range: Valley bottom to alpine.

ECOLOGY AND HABITAT REQUIREMENTS

Peregrine falcons are sturdy crow-sized falcons that specialise in direct pursuit of small to medium-sized birds. They favour non-forested areas to hunt, particularly along shores, marshes, and river valleys and primarily nest on cliffs. They prefer habitats that support large numbers of shorebirds, waterfowl and other small to medium size birds. In the interior, marshes, lakeshores, river mouths, airports, broad river valleys, and cities (in winter) are utilised. In autumn, migrants have been found in alpine meadows up to 2410m elevation (Campbell *et al*., 1990).

Peregrines primarily nest on cliffs, but will use abandoned eagle or ravens nests adjacent to rivers or lakes in the interior (Canadian Wildlife Service, 1990; Campbell *et al*., 1990, Ehrlich *et al.*, 1988). Other nests have been found on grassy benches of rocky bluffs, abandoned nests of Pelagic Cormorants and Bald Eagles (Campbell *et al.,* 1977), eroded banks of watercourses, hills, slopes, dykes, and, where the terrain is quite level, on boulders, hummocks, or on the ground (Palmer, 1988). They will generally nest where there is a good food supply, such as near colonies of white-throated swifts and violet green swallows, bats and waterfowl (Snyder and Snyder, 1991).

The heights of cliffs where nests have been sighted ranged from 12 to 366 meters, with 50% recorded between 23 and 38 meters. Most nesting ledges were sheltered by over hanging grass sods, rocks, tree roots, salal, or mosses. Interior aeries are situated on ledges in rocky bluffs overlooking large lakes and rivers (Campbell *et al.,* 1990). On the coast, 93% of nests are situated on ledges of vertical rocky cliffs. Nest ledges have ranged from 0.3 to 4.6 m deep, and 0.3 to 2.4 m wide. Nesting materials are not usually used, but some aeries are littered with prey remains, bits of leaves, grasses and mosses, and decayed wood. Interior aeries have been situated on ledges in rocky bluffs overlooking large lakes and rivers and cliff face heights have ranged from 6 to 260m.

Peregrine nest site selection is often difficult to predict. In parts of Alaska, they frequently use a low bluff only a few hundred meters from a high cliff; and in the foothills of the Rockies there are hundreds of square kilometres of unoccupied but apparently suitable cliffs, while "poorer" sites are occupied regularly. Ideally aeries that are chosen command a wide view, near water with plentiful prey in its vicinity and seldomly disturbed (Palmer, 1988). Similar sites may be used as plucking areas for prey that overlook an aerie (Palmer, 1988). In the Okanagan a nesting concentration of three peregrines has been recorded along a half mile of an inaccessible lakeshore cliff (Nelson, in Hickey 1969). Within a breeding territory of several kilometres, a peregrine pair usually has several alternate nest ledges (Canadian Wildlife Service, 1990). Little is known about peregrines in the northern interior of the province and habitat requirements in this area must be drawn from peregrines in the southern interior and Peale's peregrine on the coast.

Preference for prey are various types of waterfowl but they will consume a variety of other items including fish, crabs, slugs, hares, lemmings, pikas, voles, rats, chipmunks, and ground squirrels (Palmer, 1988; Synder and Snyder, 1991). They are specialised for capturing aerial prey and are very fast and agile fliers. They prefer to hunt from stationary perches in a high spot such as a prominence or a tall tree (Palmer, 1998). Some hunting is done from the aerie or nearby perches

where the male spends time sunning and preening when not hunting or delivering prey (Palmer, 1988). During natal dispersal peregrines prefer open country or water-prairies, lake and river margins, marine shorelines, beaches, dunes, and the sea (Palmer, 1988).

Territorial defence occurs to within 91.4 meters of the aerie and approaching birds that are not prey may be attacked. For example in Alaska, they attack golden eagles when more than 2 km away, but common ravens can approach to within 100 meters and rough-legged hawks within 50 meters (Palmer, 1988). Although the actively defended area is small, the entire hunting range in the breeding season can be as much as 10,000 hectares, and food supply probably determines its size (Palmer, 1988). The territory of some pairs may overlap.

In the interior, spring migration occurs from late March to early April . Fall migration may begin in August, but occurs mostly in September. Peregrine falcons rarely winter north of the Thompson Basin and the Okanagan valley in the interior (Campbell *et al*., 1990). They tend to favour migration over water because of plentiful food supply. An exception to migration are the Queen Charlotte Island birds and counter-clockwise up the continent to include the Aleutians and Commanders. They tend to be year long residents but seasonal dispersal does occur.

LIFE REQUISITES/SEASONAL USE PATTERNS

Peregrine life requisites include food, security and reproduction (Table 43).

Table 43. Peregrine falcon seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Food	Growing	March-September
2.	Security	Growing	March-September
3.	Reproduction	Growing	March-July

Food

The majority of peregrine prey items are found in and around bodies of water such as lakes, ponds, rivers and wetlands.

Security

Security for peregrine falcon refers specifically to nest security. Little is known of interior nesting requirements in BC. Campbell *et al*. (1990) reports that coastal breeding cliffs on average are 23 to 38 m in height where nest height from the base of the cliffs is 12 to 24 m in height and the nests are generally 3 to 9 m from the top of near vertical cliffs. Nest trees range in height from 12 to 20 m in height.

Reproduction

Suitable reproduction habitat is composed of security (cliffs) in close proximity to food; primarily close to an abundance of birds such as waterfowl. In the interior, peregrine nests have been located near large sources of water; lakes, rivers or wetlands, close to food.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between Peregrine falcon habitat use and TEM ecosystem and terrain attributes are described in Table 44.

Table 44. Peregrine falcon habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	The distribution of peregrine falcons in the Northern Boreal Mountains Ecoprovince, is not well known. To date, no breeding individuals have been found in this area. We assume that the WMR, EMR, MIR and CAR Ecosections provide up to moderate (50% or 3 on a scale of 1-6) peregrine falcon habitat relative to the best habitat in the province. Peregrine falcons are not found in the winter in the study area– the wetlands, lakes and ponds are frozen and provide no food.
Biogeoclimatic Zone	Peregrine falcon habitat potentially occurs in all of the subzones in the study area. The BWBSdk1 has the largest wetlands and lakes in the Study Area and therefore would provide the best habitat for food. The ESSFmv4 and SWBmk1 also provide food although prey availability will be slightly lower than the BWBSdk1, simply due to the lower abundance of prey species and lower occurrence of rivers, lakes and wetlands. The ESSFmvp4, SWBmks1 and AT provide abundant security habitat for reproduction although only low-level food habitat.
Site Series	Peregrine falcons prefer habitats that support waterfowl, shorebirds and other medium sized birds, which in the interior are found in marshes, lakeshores and large rivers. Therefore, site series with soil moisture regimes mesic, subhydric and hydric provide better food than drier xeric site series.
Structural Stage	Structural stages 01, 1a and 02 wetland sites provide optimal food. All security habitat (cliffs) are structural stage 01.
Slope	Cliffs provide security for reproduction and fledging of young. We assume that in the study area slopes between 80 and 90^{o} and greater than 20 meters in height provide optimal security. Slopes between 80 and 90^{o} and less than 20m but greater than 10m in height provide slightly lower security; and slopes less than 80^{o} and/or less than 10m in height provide no security for nesting or fledging.
Aspect	Peregrine falcons prefer south-facing aspects for nest sites (Canadian Wildlife Service, 1990).
Proximity Effects	Suitable reproduction habitat contains security (cliffs) in close proximity to food. We assume that cliffs greater than 5 km from a site that provides food provide poorer reproductive habitat.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A four-class rating scheme is used to rate peregrine falcon habitat. A six-class scheme is used in this draft because the field ratings were completed with this scale; these will be converted to the four-class scheme for the final products. Habitats are rated for food (FD), security (SH) and reproduction (RP) in the growing season (G). Habitat maps will not be produced for this species.

For those peregrines that are non-breeding and for breeders outside of the breeding season, it is assumed that habitat providing food also provides all life requisites necessary for survival but not for reproduction.

Food (FD) ratings are defined in the ratings table. Security (SH) ratings could be applied in one of two ways: using a digital elevation model (DEM) or using the map code CL (cliff). Living and reproduction habitat is found where cliffs (SH) are in close proximity to food (FD). The combinations of FD with SH will be modelled and these ratings will be generated using a GIS algorithm.

Food (FD) Habitat Assumptions

The ratings table assigns a suitability rating for FD to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between peregrine life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 45). For example, the optimal structural stage for food (low shrub) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as sparse) has a degrading score of -2, which would result in a maximum rating of 3 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Security (SH) Habitat Assumptions

SH ratings could be generated in one of two ways: using a digital elevation model (DEM) to define cliffs or using the map code CL (cliff). (Table 46).

Table 45. Peregrine food habitat assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score
			FD-G
1. BGC Unit	**EMR**	BWBSdk1	3
		ESSFmv4	4
		SWBmk1	4
		ESSFmvp4	5
		SWBmks1	5
		AT	5
	MIR	ESSFmv4	4
		ESSFmvp4	5
		AT	5
	EMR	SWBmk	4
		SWBmks	5
		AT	5
	WMR	BWBSdk1	3
		ESSFmv4	4
		SWBmk1	4
		ESSFmvp4	5
		SWBmks1	5
		AT	5
2a. Site Series (SMR)		Xeric	2
		Subxeric	1
		Submesic	0
		Mesic	0
		Subhygric	0
		Hygric	0
		Subhydric	0
		Hydric	0
2b. Site Series (SNR)		Very poor- poor	1
		Medium-very rich	0
3. Structural Stage		Sparse (1a)	0
		Bryoid (1b)	0
		Herb (2)	0
		Low shrub (3a)	0
		Tall shrub (3b)	1
		Pole/sapling (4)	2
		Young forest (5)	2
		Mature forest (6)	2
		Old forest (7)	2
3. Stand Composition		Broadleaf	0
		Mixed	0

Table 46. Peregrine security habitat use assumptions.

Topic	Description
A. Slopes (using a DEM)	Slopes between 80 and 90° and greater than 20 meters in height and rated 1 SH. Slopes between 80 and 90° and less than 20m but greater than 10m in height are rated 3 SH. Slopes between 80 and 90° and less than 10m in height rated 6 SH.
B. Cliffs	Polygons containing the map label CL will be rated 1 SH.

Reproduction (RP) Habitat Assumptions

Suitable reproduction habitat contains security (cliffs) within 5 km of habitat that provides food (Table 47).

Table 47. Peregrine Falcon reproduction habitat assumptions.

Topic	Description
1. Proximity effects	RP is equal to lower rating between the polygon SH and the best FD rating within 5 km.
2. Aspect	Warm aspects (135-285°) rated up 1 RP. Cool aspects (285-135°) rated down 1 RP.

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3.13 Yellow-bellied Flycatcher (*Empidonax flaviventris*)

SPECIES NAME: Yellow-bellied Flycatcher
SCIENTIFIC NAME: *Empidonax flaviventris*
SPECIES CODE: B-YBFL
STATUS: Blue listed (MELP, 1997); not at risk (COSEWIC, 1998)

DISTRIBUTION

Provincial Range

The Yellow-bellied Flycatcher breeds from west central to northeastern and east-central British Columbia. (Campbell *et al*., 1997). Uncommon in BC, they have been documented breeding in central-western and southern Mackenzie areas such areas as Fort Norman, Soulier Lake, Nahanni National Park, Donna Creek (80 km WNW of Mackenzie). They are found in greater abundance in northern BC such as Dease Lake area, Atlin, Muskwa River, Trutch and McDonald Creek (Campbell *et al*., 1997).

Provincial Benchmark

Ecoprovince:
Ecoregion:
Ecosection:
Biogeoclimatic zone:
Broad Ecosystem Units:

Not officially established but likely in the Taiga Plains Ecoprovince (Campbell *et al*., 1997).

Project Study Area

Ecoprovince: Northern Boreal Mountains
Ecoregion: Northern Mountains and Plateaus and Northern Rocky Mountains
Ecosection: Cassiar Ranges (CAR), Western Muskwa Ranges (WMR), Eastern Muskwa Ranges (EMR) and Missinchninka Ranges (MIR)
Biogeoclimatic zone: BWBSdk1, ESSFmv4 and SWBmk1
Elevational range: Valley bottom to 1000 m.

ECOLOGY AND HABITAT REQUIREMENTS

Yellow-bellied flycatchers are neotropical migrant birds, spending their summers in northern coniferous forest, muskegs and boreal bogs. They arrive in BC in early- to mid-June and return to wintering areas in Mexico, Central and South America in August to early September. During the summer, they are sparsely distributed in the northern two-thirds of BC where they occupy

much of the Taiga and Boreal Plains and occur locally in the southern portions of the Sub-Boreal Interior Ecoprovince (Campbell *et al*., 1997)

Preferred habitats for Yellow-bellied Flycatcher are forested palustrine wetlands, forest edges, second growth woodlands (20-40 years old) and swampy areas, including edges of open trembling aspen stands, second-growth deciduous woodlands, white birch near beaver ponds, and flooded swamps.
They are different from other Empidonax flycatchers in that they tend to frequent the lower branches of vegetation and avoids more exposed perches. Favourite nesting areas and territories have been identified to contain spruce-fir bogs with a secondary composition of paper birch-pine trees, mountain ash, cranberries, trailing white snowberries, and lush moss carpets of sphagnum.

Elevation preferred in the Appalachian mountains is about 800m while Campbell *et al.* (1997) report that they breed in BC at 400-600 m elevation. Campbell *et al*. (1997) reports that breeding has not been recorded in the Northern Boreal Mountains Ecoprovince however breeding is reported to occur from late-June to early-July in other areas of the province.

Nests are usually built on or near the ground in a shallow cavity among roots of a fallen tree, in a hummock of dense sphagnum moss and usually not more than two feet above the ground (Bent, 1963; Ehrlich *et al.*, 1988; Godfrey, 1986). The only nest in BC for which details were given was situated on the ground, sunk into a mossy hummock (Campbell *et al*., 1997), typical of Yellow-bellied Flycatchers throughout their range (Bent, 1963; Ehrlich, *et al.*, 1988; Godfrey, 1986).

The usual foraging behaviour is that of most flycatchers: staying close to ground, perching on lower branches and rarely using exposed or high perch sites, flycatching and hawking insects on the ground and in the air. Most common prey items are beetles, bees, wasps, ants, moths, butterflies, flies, grasshoppers and spiders. A small amount of their diet may include seeds and berries.

Migrational movements in BC have not been documented well but movement occurs throughout early June in spring. As with most passerines, the males precede the females to breeding grounds and younger year birds follow after the elder ones (L. Michalak pers. comm.). After nesting season autumn movement occurs from late July to August with adult birds being recorded in Mackenzie as late as August 25 D. (Lambie pers. comm.).

LIFE REQUISITES/SEASONAL USE PATTERNS

Yellow-bellied flycatcher seasonal life requisites are divided into reproduction and security/food (Table 48).

Table 48. Yellow-bellied flycatcher seasonal life requisites.

Rank	Life Requisite	Season	Months
1.	Reproduction	Growing	June-July
2.	Security/Food	Growing	May-September

Reproduction

We assume that optimal reproduction habitat is young to mid-aged (20-40 year old), moist to wet, mixed-wood and coniferous forests and willow swamps.

Security/Food

Habitat requirements for Yellow-bellied Flycatcher outside of the reproductive period include security and food. Security, which is likely related most to protection from predators and protection during nesting, is provided by thick vegetation in shrubs or the lower branches in riparian areas of trees of a variety of different cover types. Food may be found wherever insects are abundant and there is adequate security. This includes forests edges (riparian strips) and wetlands of various structural stages. Habitats are not rated for security and food outside of the reproductive period. It is described here only for completeness.

HABITAT USE AND ECOSYSTEM ATTRIBUTES

The relationship between Yellow-bellied Flycatcher habitat use and TEM ecosystem and terrain attributes are described in Table 49.

Table 49. Yellow-bellied Flycatcher habitat use related to TEM ecosystem and terrain attributes.

TEM Attribute	Habitat Use
Ecosection	The distribution of Yellow-bellied Flycatcher in the Northern Boreal Mountains Ecoprovince is not well known. To date, no breeding individuals have been found in this area. Given that the highest numbers have been found in the Taiga Plains and then in the Sub-Boreal Interior, we assume that the WMR, EMR, MIR and CAR Ecosections provide up to low (25%) Yellow-bellied Flycatcher habitat relative to the best habitat in the province.
Biogeoclimatic Zone	Yellow-bellied flycatchers can be potentially found in all the BGC Zones lower then 1000m in elevation in the Mackenzie TEM study area. This includes the BWBSdk1, ESSFmv4 and the SWBmk1.
Site Series	Subhydric to hygric site series provide better habitat than the drier site series for living. Yellow-bellied flycatchers prefer habitats that support a high number of insects, which in the interior would include marshes, beaver ponds and willow swamps (Campbell *et al*., 1997).
Structural Stage	Young to mid-aged forests provide the best reproductive habitat. Therefore, dense structural stages 3b (tall shrub) to 05 (young forest) are rated highest.
Elevation	Campbell *et al*. (1997) reports habitat use up to 1000 m. Habitats above this elevation are rated lower.

HABITAT RATINGS

Rating Scheme/Modelling Theme

A four-class rating scheme is used to rate reproduction habitat in the growing season (G). A six-class scheme is used in this draft because all of the field ratings were completed with this system and these will be converted to the four-class scheme for the final ratings. Habitat maps are not being produced for this species.

This model depicts habitat used for reproduction, a combination of security and food. These areas will also be used by the bird outside of the reproductive period. They must also provide adequate food and security for general living. Yellow-bellied flycatchers will also find food in a variety of other habitat types that are otherwise unsuitable for reproduction, and these areas are assumed to be not-limiting.

Reproduction (RP) Habitat Assumptions

The ratings table assigns a suitability rating for RP to each ecosystem unit. An ecosystem unit is a combination of site series and structural stage. The relationship between Yellow-bellied Flycatcher life requisites and the ecosystem attributes are defined by a degrading score relative to the optimal value for the attribute (Table 50). For example, an optimal structural stage for RP (tall shrub) has a degrading score of "0"– no degrading effect. However, a sub-optimal structural stage (such as mature forest) has a degrading score of -4, which would result in a maximum rating of 3 on a scale of 1 to 6. By summing the degrading scores over all of the ecosystem attributes, a final rating is calculated. See Section 2.5 for a full description of the methodology used to generate the ratings table.

Reproduction (RP) Habitat Adjustments

Adjustments are used to modify the ratings in order to account for the species' habitat attributes that are not inherent features of the ecosystem unit.

- All polygons higher than 1000 m will be rated down 1.

Table 50. Yellow-bellied flycatcher reproduction habitat assumptions. Each number represents a degradation score. A rating for an ecosystem unit is generated by summing the degradation scores over all attributes.

Attribute		Value	Degrading Score
			FD-G
1. BEC Unit	**CAR**	BWBSdk1	3
		ESSFmv4	3
		SWBmk1	3
		ESSFmvp4	5
		SWBmks1	5
		AT	5
	MIR	ESSFmv4	3
		ESSFmvp4	5
		AT	5
	EMR	SWBmk	3
		SWBmks	5
		AT	5
	WMR	BWBSdk1	3
		ESSFmv4	3
		SWBmk1	3
		ESSFmvp4	5
		SWBmks1	5
		AT	5
2a. Site Series (SMR)		Xeric	1
		Subxeric	1
		Submesic	0
		Mesic	0
		Subhygric	0
		Hygric	0
		Subhydric	0
		Hydric	0
2b. Site Series (SNR)		Very poor- poor	1
		Medium-very rich	0
3. Structural Stage		Sparse (1a)	2
		Bryoid (1b)	2
		Herb (2)	1
		Low shrub (3a)	0
		Tall shrub (3b)	0
		Pole/sapling (4)	1
		Young forest (5)	1
		Mature forest (6)	1
		Old forest (7)	1
4. Stand Composition		Broadleaf	0
		Mixed	0

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4.0 RATINGS TABLE AND POLYGON RATINGS

One of the main products of the wildlife component is the ratings table. The ratings table contains a habitat suitability rating for each season and use for each species for each ecosystem unit in the Study Area. The ratings table is very large (there are 5236 ecosystem units in the Akie and Pesika Landscape units) and is included as Appendix C. It is also provided in a digital form on the accompanying computer disk.

The ratings from the ratings table have also been applied to the TEM map polygons. This data is also provided on the accompanying computer disks.

There are several issues that users must be aware of when viewing or using the habitat mapping.

1. Highly rated habitats are areas where animals are likely to occur, if they are present in the area. This may or may not correspond to areas with high animal use (areas that are currently occupied). There are many reasons why animals may not occupy suitable habitat:

   - Interspecific competition (an area is already occupied by another species);
   - Annual variability;
   - Predation (high predator densities);
   - Social interactions (social interactions can cause subdominant individuals to inhabit lower quality areas, potentially resulting in even higher animal densities than in higher quality habitat (RIC, 1998a));
   - Disease;
   - Human disturbance; or
   - Factors that determine distribution that are currently unknown.

   Since animal distribution is dynamic, areas that are unoccupied now may become occupied at a future time through natural range expansion, loss of currently occupied habitat or other factors. This is where the strength of habitat mapping lies: by understanding both current distribution and the availability of suitable habitat, predictions about future habitat occupancy can be made.

2. Most of the TEM polygons are complexes of two or three ecosystem units. Since only one of these ecosystems may be of value for a specific season and use, the exact location of an important habitat may be difficult to determine. To determine exact location (sub-polygon accuracy), a site-visit or photo-interpretation using high-quality recent photos is required.

3. The maps represent the state of the terrain and vegetation as it was observed in 1996-98 (through site visits and air-photos). Changes to vegetation (through man-made modifications or through natural succession) will continue to have an influence on the distribution and dynamics of wildlife habitat.

4. The mapping is based on models that are applied to the TEM data in a uniform fashion. Point features, such as mineral licks, are not depicted and are therefore not incorporated into the model. Consequently, animals may be found in areas that are otherwise not suitable (e.g., there is no food or security).

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APPENDIX A: SITE SERIES EXPANDED LEGEND

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
AT			SD	2	Sedge-Dwarf willow moist meadow	Sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso gentle slopes, deep coase textured soil	cdj	Mesic - subhygric	fsvkw
AT			AD	2	Mountain arnica - Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level coarse textured soils, usually deep, found below 1900m.	djm	Mesic - subhygric	fsvkw
AT			WA	3ab	Willow-Mountain arnica moist meadow	Shrub willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level coarse textured soils, usually deep ususally below 1900m.	cdj	Subhygric - submesic	fsvkw
AT			AW	2	Mountain avens-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv,C	Crest - upper slopes, shallow soils, significant slopes coarse texutured soils	jms	Subxeric - submesic	fjkwv
AT			FL	2	Alpine fescue - Lichen dry meadow	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx,Cv	shallow soils, gentle slopes - rapidly drained coarse textured	jms	very xeric - subxeric	dmkw
AT			HS	2	Horsetail-Sedge fen	Sedges & horsetail	O, Fb	depression, peaty gentle slopes deep soils	pjd	Hygric - subhydric	md
AT			FH	3a	Bl-Heather mesic krumholtz	Alpine fir mats under which dwarf willow , heathers and assorted herbs including mountain sagewort may also occur	Variable	rapidly to moderately well drained, shallow coarse textured soils	sc	Subxeric - mesic	fvdkw
AT			VH	2,3ab	Sitka valerian - Indian hellebore avalanche track	Moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Shrub willow dominated phase also recognized which has same herbaceous understory	Variable	Well to imperfectly drained . Avalanche tracks, significant slopes, deep, medium textured soils	dc	Hygric - subhygric	kwcs
AT			GL	N/A	glacier	no vegetation					
AT			PS	N/A	permanent snow	no vegetation					
AT			PG	1a	patterned ground	variable invader species chiefly annual herbs	M	mostly level to gentle slopes		mesic-subhygric	f,m
AT			SO	1a	solufluction	variable invader species chiefly annual herbs	M,C	gentle slope or greater		mesic-subhygric	f,m

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
AT			MO	1a	moraine	variable	M			variable	c,f,m,k,w,s,d
ESSF	mvp4		SD	2	Sedge - Dwarf willow moist meadow	Sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, gentle level, lower to upper meso slopes, deep, medium textured soil	djm	Mesic - subhygric	cfsvkw
ESSF	mvp4		AD	2	Mountain arnica-Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Mesic - subhygric	cfsvkw
ESSF	mvp4		WA	3ab, 3am, 3bb	Willow-Mountain arnica moist meadow	Tall willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Subhygric - submesic	cfsvkw
ESSF	mvp4		AW	2	Mountain aven-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	sc	Subzeric - submesic	fjkwv
ESSF	mvp4		FL	2	Alpine fescue-Lichen dry meadow	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx, Cv	Gentle slopes, medium-textured, shallow soils	jms	Subxeric - submesic	vdmkw
ESSF	mvp4		HS	2	Horsetail-Sedge fen	Sedges & horsetail	O, Fb	depression	pjd	Hygric - subhydric	md
ESSF	mvp4		FH	3a, 3am	BL-Heather krumholtz	Alpine fir mats under which dwarf willow , heathers and assorted herbs including mountain sagewort may also occur	variable	rapidly to moderately well drained, gentle shallow medium textured soils	jms	Subxeric - mesic	vkwcf
ESSF	mvp4		FF	3a, 3am, 3ab, 3b	Bl-feathermoss avalanche track	Bl, bog birch feathermosses assorted high elevation herbs	C, M	significant slope, deep medium textured soils	dm	mesic - subxeric	wkvsc
ESSF	mvp4		VH	2,3ab	Sitka valerian - Indian hellebore avalanche track	Moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	significant slope, deep medium textured soils	dm	subhygric - hygric	kw
ESSF	mvp4		FR	3a-7 - same as ESSFmv4	Bl-Rhododendron - Feathermoss	Se-Bl-white-flowered rhododendron black huckleberry, bunchberry, mountain sagewort, feathermosses	variable	upper-mid level, deep medium textured soils	dmj	Mesic	wkcfsv
ESSF	mvp4		FW	3a-7 - same as ESSFmv4	Bl-Rhododendron - Wildrye	Se-Bl-Pl-White flowered rhododendron, black huckleberry, soopolallie, altai fescue, feathermosses	variable	significant slopes, warm aspect, deep, medium textured soils	wdm	submesic	kcfsv

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
ESSF	mvp4		LC	3a-7 - same as ESSFmv4	BlPl-Crowberry - Cladina	Pl-Se-white flowered rhododendron, black huckleberry, twinflower, crowberry, feathermosses, lichens	coarse, shallow soils or F^G	coarse textured shallow ridged , gentle slope	csrj	subxeric-xeric	dvfwk
ESSF	mvp4		BT	3a-7 - same as ESSFmv4	BlSb - Labrador tea	Pl-Sb-Bl- white-flowered rhododendron, black huckleberry, Labrador tea, twinflower, lingonberry, feathermosses	variable	deep medium textured soils, gentle slope	djm	subxeric-subhygric	svfc
ESSF	mvp4		RH	3a-7 - same as ESSFmv4	BL - Rhododendron - Horsetail	Se-Bl-white-flowered rhododendron black huckleberry, bunchberry, bluebells, dwarf scouring rush feathermosses	variable	deep mdium textured soils, gentle slope	djm	subhygric	cfwkvs
ESSF	mvp4		GL	N/A	glacier	no vegetation					
ESSF	mvp4		PS	N/A	peramanent snow	no vegetation					
ESSF	mvp4		PG	1a	patterned ground	variable invader species chiefly annual herbs	M	mostly level to gentle slopes		mesic-subhygric	f,m
ESSF	mvp4		SO	1a	solufluction	variable invader species chiefly annual herbs	M,C	gentle slope or greater		mesic-subhygric	f,m
ESSF	mvp4		MO	1a	moraine	variable	M			variable	c,f,m,k,w,s,d
SWB	mks		SD	2	Sedge - Dwarf willow moist meadow	sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso slopes, medium textured soil	dmj	Mesic - subhygric	cfsvkw
SWB	mks		AD	2	Mountain arnica - Subalpine daisy meadow	dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	dmj	Mesic - subhygric	cfsvkw
SWB	mks		WA	3ab,3am 3bb, 3bm	Willow - Mountain arnica moist meadow	Willow - Mountain arnica moist meadow	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	dmj	Subhygric - submesic	cfsvkw
SWB	mks		AW	2	Entire leaved mountain avens - Dwarf willow	dry herb-grass, dwarf willows, bog birch, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	jms	Subzeric - submesic	fkwv
SWB	mks		SA	3ab, 2	Scrub birch - Altai fescue	dominated by alpine grasses altai fescue, bog birch, arctic poas and high mixed lichen cover, crowberry, lingonberry	Dx, Cv	gentle slopes, deep , medium textured soils	djm	Subxeric - submesic	dsmkw
SWB	mks		HS	2	Horsetail - sedge fen	Horsetail - Sedge fen	O, Fb	depression, organic	pjd	Hygric - subhydric	

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mks		FH	3a	BL-Heather krumholtz	alpine fir mats under which dwarf willow , bog birch, heathers and assorted herbs including mountain sagewort may also occur	variable	significant slope, shallow, medium textured soils	sm	Subxeric - mesic	vkwc
SWB	mks		FF	3a, 3am, 3b	Bl-Feathermoss avalanche track	Bl, bog birch, willow, feathermosses assorted high elevation herbs	C, M	significant slopes, deep, medium textured soils	dm	mesic - subxeric	wk
SWB	mks		VH	2,3am,3ab	Sitka valerian - Indian hellebore avalanche track	moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	significant slopes, cool aspect shallow coarse textured soil	cks	subhygric-hygric	w
SWB	mks		SB	all SWB st. stages	Sw-Grey-leaved willow-Scrub birch	Sw - Bl, bog birch, shrub willows, mountain sagewort, Sitka valerian, feathermosses	variable	mid-upper, level, gentle slope, deep medium textured soils	dmj	Mesic - subhygric	wkscsv
SWB	mks		SC	all SWB st. stages	Sw-Scrub birch-Bluejoint	At - Sw,-Sb Labrador tea, shrub willow, crowberry, lingonberry, feathermoss	variable	level, upper-lower, significant slope, cool aspect, deep medium textured soils	kdm	subhygric	svfc
SWB	mks		SK	all SWB st. stages	Sw-Juniper-Wildrye	Sw-Bl, juniper, soopolallie, shrubby cinquefoil, bog birch, red bearberry, death camus, northern goldenrod,	Cv,F, F^{G}	warm aspect significant slope deep, medium textured soils, warm aspect	dmw	subxeric	s
SWB	mks		SL	all SWB st. stages	Sw-Willow-Crowberry	Sw - Labrador tea, bog birch, willow, lingonberry, feathermoss	variable	significant slope, cool aspect, deep medium textured soils	kdm	submesic-subhygric	svfc
SWB	mks		SS	all SWB st. stages	Sw - Willow-Stepmoss	Sw- Bl shrub willow, Labrador tea, bog birch, lingonberry, bluebells, feathermoss	M,F	deep , medium textured soils, gentle slope	djm	Subhygric	vscwk
SWB	mks		SW	all SWB st. stages except 2	Sw-Arctic lupine-Stepmoss	Sw- shrub willow, soopolallie, Labrador tea, fuzzy wildrye, lingonberry, feathermoss	F^{G},C,M	crest - upper warm aspect	djm	Xeric - Subxeric	svc
SWB	mks		PL	all SWB st. stages	Pl - Scrub birch - Cladina	Sw - Bl - Pl Soopolallie, Salix, fuzzy wildrye, lichens, feathermosses	shallow to bedrock	significant slope , warm aspect, shallow soils	sw	very xeric - xeric	k
SWB	mks		GL	N/A	glacier	no vegetation					
SWB	mks		PS	N/A	peramanent snow	no vegetation					
SWB	mks		PG	1a	patterned ground	variable invader species chiefly annual herbs	M	mostly level to gentle slopes		mesic-subhygric	f,m
SWB	mks		SO	1a	solufluction	variable invader species chiefly annual herbs	M,C	gentle slope or greater		mesic-subhygric	f,m
SWB	mks		MO	1a	moraine	variable	M			variable	c,f,m,k,w,s,d

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mk1		SB	all	Sw-Grey-leaved willow - Scrub birch	Sw - Bl, bog birch, shrub willows, feathermoss	variable	mid-upper, level, gentle slope, deep medium textured soils	mdj	mesic	svfcwk
SWB	mk1		PL	all	Pl - Scrub birch - Cladina	Sw - Bl - Pl Soopolallie, Salix, fuzzy wildrye, lichens, feathermosses	shallow to bedrock	significant slope , warm aspect, shallow soils	sw	very xeric - xeric	k
SWB	mk1		SK	all	Sw-Juniper-Wildrye	Sw-Bl, juniper, soopolallie, shrubby cinquefoil, bog birch, red bearberry, death camus, northern goldenrod,	Cv,F, F^{G}	crest upper, warm aspect	dmw	subxeric	s
SWB	mk1		SW	all	Sw-Arctic lupine - Step moss	Sw- shrub willow, soopolallie, Labrador tea, fuzzy wildrye, lingonberry, feathermoss	F^{G},C,M	gentle , deep, medium textured	djm	Xeric - Subxeric	svc
SWB	mk1		SL	all	Sw-Willow-Crowberry	Sw - Labrador tea, bog birch, willow, lingonberry, feathermoss	variable	upper-lower, significant slope, cool aspect, deep medium textured soils	kdm	submesic-subhygric	svfc
SWB	mk1		SC	all	Sw- Scrub birch - Bluejoint	Sw,-Sb Labrador tea, shrub willow, crowberry, lingonberry, feathermoss	variable	upper-lower on northerly aspect, significant slope, deep medium textured soils	kdm	subhygric	svfc
SWB	mk1		SS	all	Sw - Willow - Step moss	Sw- Bl shrub willow, Labrador tea, bog birch, lingonberry, bluebells, feathermoss	M,F	lower toe, gentle slope, deep medium textured soils	djm	Subhygric	vscwk
SWB	mk1		SH	all	Sw - Shrubby ciquefoil - Horsetail	Sw- shrub willow, bog birch, , horsetail, bluebells, coltsfoot, northern sweet-vetch, blue stem, polar grass, feathermoss	F	toe, depression, gentle slope, deep coarse textured soils	cdj	Hygric	vsmwk
SWB	mk1		SD	2	Sedge - Dwarf willow moist meadow	sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso slopes, medium textured soil	dmj	Mesic - subhygric	cfsvkw
SWB	mk1		AD	2	Mountain arnica-Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Mesic - subhygric	cfsvkw
SWB	mk1		WA	3ab, 3am, 3bb	Willow-Mountain arnica moist meadow	Tall willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Subhygric - submesic	cfsvkw
SWB	mk1		AW	2	Mountain aven-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	sc	Subzeric - submesic	fjkwv
SWB	mk1		SA	2	Scrub birch - Altai fescue	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx, Cv	Shallow coarse textured soils - rapid drained	jms	Subxeric - submesic	vdmkw

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
SWB	mk1		BJ	2	Bluejoint - Avens high meadow	Mixed grasses, sedges, tall larkspur, large leaf aven, dwarf nagoonberry, meadow rue	variable	lower, depression, cold air ponding, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfwk
SWB	mk1		WG	3ab,3am, 3bb,3bm	Willow - Groundsel shrub carr	Shrub willow, bog birch, mixed grasses, sedges, Sitka valerian, arrow leaved groundsel, large leaf geum	variable	lower, depression, cold air ponding, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfwk
SWB	mk1		VH	2,3ab,3am 3bb,3bm	Sitka valerian - Indian hellebore avalanche track	moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	Well to imperfectly drained. Avalanche tracks, significant slopes slopes	dm	Hygric - subhygric	kw
SWB	mk1		BP	2,3ab	Bluejoint - Cow parsnip avalanche track	Blue joint, bluebells, cow parsnip, white geranium, stinging nettle, tall larkspur, meadowrue, Canada violet, wild strawberry, trailing raspberry. Willow dominated phase also recognized with the same herbaceous understory	variable	Well to imperfectly drained. Avalanche tracks, significant slopes	dm	Hygric - subhygric	kw
SWB	mk1		MW	2,3ab	Water sedge - Fen moss fen	carex lasiocarpa, carex aquatilis	O	Depression, organic	pjd	Hydric	
SWB	mk1		SE	2,3ab+E1 55	Sedge - Asphodel fen	carex, Trichohorum caespitosum	O	Depression, organic	pjd	Hydric	
SWB	mk1		WE	3a,3ab,3b, 3bb,4,etc to 7	Willow - Scrub birch fen edge	Stunted spruce, willow, Labrador tea	O	Depression, organic	pjd	Hydric	
SWB	mk1		FS	2	Slender sedge - Fen moss fen	Sedges, trichophorum caespitosum	O	Depression, organic	pjd	Hydric	
SWB	mk1		WP	2,3ab	Water sedge - Bristle stalked sedge perched fen	Sedges, willow, bog birch, horsetail	O	Depression, organic	pjd	Hydric	
SWB	mk1		LG	2,3ab, 3b	Labrador tea - Glow moss sloping fen	Sedges, willow, bog birch, Labrador tea, horsetail	O	Depression, organic	pd	Hydric	wk
SWB	mk1		FB	2,3ab	Scrub birch - Sedge fen	Bog birch, willows, carex, fen edge	O	Depression, organic	pjd	Hydric	
SWB	mk1		FF	3a, 3b, 3am	Bl-Feathermoss avalanche track	Bl, bog birch feathermosses assorted high elevation herbs	C, M	significant slopes, deep, medium textured soils	dm	mesic - subxeric	wk
BWBS	dk1	01	SM	all	Sw -Knight's plume - Step moss	Sx-Pl - highbush cranberry, prickly rose, soopolalie, one-sided wintergreen, bunchberry, feathermosses	variable	deep, coarse textured soils, gentle slopes	cdj	submesic - subhygric	svfwk

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
BWBS	dk1	02	LL	all	Pl- Lingonberry - Feathermoss	Pl-Sw- soopolallie, lingonberry, kinnickinik, dwarf blueberry, lichens,	Dx, Cv, F^{G}b	deep, coarse textured soils, gentle slopes	cdj	subxeric - xeric	svfwk
BWBS	dk1	03	Sw	all	Sw- Wildrye - Feathermoss	Pl-Sw- soopolallie, fuzzy spiked wildrye, twinflower, feathermosses	variable	significant slope, warm aspect, deep, medium textured soils	dmw	Submesic - subxeric	svfc
BWBS	dk1	04	BL	all	Sb - Lingonberry - Knight's plume	Pl-Sw-Sb- Labrador tea, soopolallie, lingonberry, crowberry, feathermosses	F^{G},M	north or level, gentle slopes, deep, medium textured soils	dmj	xeric-mesic	ksvfc
BWBS	dk1	05	SS	all	Sw - Soopolallie - Twinflower	Pl- soopolallie, prickly rose, twinflower, kinnikinnick, bastard toadflax, feathermoss	variable	upper, north or level, gentle slopes, deep, coarse textured soils	cdj	Submesic - mesic	ksvfm
BWBS	dk1	06	SR	all	Sw - Scouring rush - Step moss	Sw-black current, highbush cranberry, dwarf scouring rush, bluebells, feathermosses	variable	lower - toe receiving sites, gentle slopes, deep, medium textured soils	djm	Subhygric	cvfwk
BWBS	dk1	07	BC	all	Sb - Lingonberry - Coltsfoot	Pl-Sw-Sb- Labrador tea, prickly rose, willow, lingonberry, feathermosses	Mb, F, O	Lower, toe, level - depression, gentle slopes, deep, medium textured soils	djm	Subhygric - hygric	kpcf
BWBS	dk1	08	SC	all	Sw - Currant - Horsetail	Sw-black current, mountain alder, highbush cranberry, horsetails, common mitrewort, bluebells, feathermosses	F,O	level - toe, streamside, gentle slope, deep medium textured soils	dm	Subhygric - hygric	cvfwkj
BWBS	dk1	09	BH	all	Sb - Horsetail - Sphagnum	Sb-Labrador tea, willows, horsetails, sedges, bog cranberry, sphagnum mosses, step moss, glow moss	O	level - toe - depression, organic	pj	subhydric - hygric	
BWBS	dk1		SO	all	Sw- Oak fern	Sw-Devils club, currants, high bush cranberry, oak fern, bluebells, common mitrewort, feather mosses	variable	lower, toe, gentle slope, deep medium textured soils	dmj	subhygric	vfcwk
BWBS	dk1		SO:ao	all	At - Oak fern	At-Bi-Sw-Devils club, currants, high bush cranberry, oak fern, bluebells, common mitrewort, feather mosses	variable	lower, toe, gentle slope, deep medium textured soils	dmj	subhygric	vfcwk
BWBS	dk1		KS	2	Kinnikinnik - Sage grassland	Common juniper, kinnikinnick, sages, spikelike goldenrod, cut leaf anemone, grasses	shallow soils or F^{G}	crest, significant slope, warm aspect, sometimes shallow soils	w	very xeric - subxeric	vscd
BWBS	dk1		BP	2, 3ab	Bluejoint - Cow parsnip avalanche track	Blue joint, bluebells, cow parsnip, white geranium, stinging nettle, tall larkspur, meadowrue, Canada violet, wild strawberry, trailing raspberry. Willow dominated phase also recognized with the same herbaceous understory	variable	Well to imperfectly drained. significant slopes, deep, medium textured soils	dm	subhygric - hygric	kw
BWBS	dk1		BB	2,3ab	Scrub birch - Beaked sedge fen	Carex lasiocarpa, carex aquatilis or utricularis	O	depression, organic	pjd	hydric	n/a

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
BWBS	dk1		SE	2,3ab	Sedge- Asphodel fen	Carex, Trichohorum caespitosum	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		WE	3ab,3b	Scrub birch - Willow fen edge	Stunted spruce, willow, Labrador tea	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		FS	2	Slender sedge - Fen moss fen	Carex	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		FB	2,3ab	Scrub birch - Sedge fen	Birch willow carex	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		HG	2	Horsetail - Giant water moss oxbow marsh	Equisetum fluvitale	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		RS	2	Rush - Sedge marsh	Scirpus lacustris	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		KR	2	Kalm's lobelia - Rush marl flats	Lobelia kalmii, sedges, rushes	O	depression, organic	pjd	hydric	n/a
BWBS	dk1		PW	3ab,3b	Pacific willow - Dogwood low bench riaprian	Salix lasiandra, Equisetum pratense	O	depression, organic	pjd	hydric	n/a
ESSF	mv4	01	FR	all	Bl-Rhododendron - Feathermoss	Se-Bl-white-flowered rhododendron black huckleberry, bunchberry, feathermosses	variable	mid-upper or level, gentle slopes, deep, medium textured soils	dmj	mesic-submesic	wkvsc
ESSF	mv4	02	LC	all	BlPl - Crowberry - Cladina	Pl-Se- white-flowered rhododendron, black huckleberry, twinflower, crowberry, feathermosses, lichens	coarse, shallow soils or F^G	crest-upper, ridge or gentle slope, deep medium textured soils	djmr	subxeric-xeric	vfwk
ESSF	mv4	03	BT	all	BlSb - Labrador Tea	Pl-Sb-Bl- white-flowered rhododendron, black huckleberry, Labrador tea, twinflower, lingonberry, feathermosses	variable	upper - lower, often northerly, gentle slope, deep medium textured soils	djm	subxeric-subhygric	svfc
ESSF	mv4	04	RH	all	BL - Rhododendron - Horsetail	Se-Bl-white-flowered rhododendron black huckleberry, bunchberry, bluebells, dwarf scouring rush feathermosses	variable	mid-toe, gentle slope, deep medium textured soils	djm	subhygric	cfwkvs
ESSF	mv4	05	FH	all	Bl - Alder - Horsetail	Se-Bl- - Sitka alder, willows, Labrador tea, currants, common horsetail, bluebells, arrow leaved groundsel, leafy mosses	F, O	level - depression, gentle slope, deep medium textured soils	dmj	hygric	cfvs
ESSF	mv4		FW	all	Rhododendron - Wildrye	Se-Bl-Pl-White flowered rhododendron, black huckleberry, soopolallie, fuzzy spiked wildrye, feathermosses	variable	upper slopes, significant slopes, warm aspects, deep, medium textured soils	wdm	subxeric-submesic	cfvs
ESSF	mv4		FF	3a, 3am, 3b	Bl-Feathermoss avalanche track	Bl, rhododendron, feathermosses assorted high elevation herbs	C, M	significant slopes, deep, medium textured soils	dm	mesic - subxeric	wk

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
ESSF	mv4		AD	2	Mountain arnica-Subalpine daisy meadow	Dominated by lush moisture loving herbs including alpine daisy, mountain sagewort, lupine, meadow rue along with mixed grasses.	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Mesic - subhygric	cfsvkw
ESSF	mv4		WA	3ab, 3am, 3bb	Willow-Mountain arnica moist meadow	Tall willow and moisture loving herbs as in DM unit	variable	Lower to upper meso slopes & level medium textured soils, usually deeper than .5m below 1900m.	djm	Subhygric - submesic	cfsvkw
ESSF	mv4		AW	2	Mountain aven-Dwarf willow	Dry herb-grass, dwarf willows, dwarf shrub typically including avens, heathers, altai fescue, arctic poas, alpine bistort, gentians	Dx, Mv, C	Crest - upper slopes, shallow soils	sc	Subzeric - submesic	fjkwv
ESSF	mv4		FL	2	Alpine fescue-Lichen dry meadow	Dominated by alpine grasses altai fescue, arctic poas and high mixed lichen cover	Dx, Cv	Shallow coarse textured soils - rapid drained	jms	Subxeric - submesic	vdmkw
ESSF	mv4		BJ	2	Bluejoint - Avens high meadow	Mixed grasses, sedges, tall larkspur, large leaf aven, dwarf nagoonberry, meadow rue	variable	lower, depression, cold air ponding, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfcwk
ESSF	mv4		WG	3ab	Willow - Groundsel shrub-carr	Shrub willow, bog birch, mixed grasses, sedges, Sitka valerian, arrow leaved groundsel, large leaf guen	variable	lower, depression, gentle slopes, deep, medium textured soils	mdj	mesic - hygric	cvfcwk
ESSF	mv4		VH	2,3ab	Sitka valerian - Indian hellebore avalanche track	moist herbs and grasses including indian hellebore, Sitka valerian, cow parsnip, arrow leaved groundsel and grasses. Willow dominated phase also recognized which has same herbaceous understory	variable	Well to imperfectly drained. significant slopes, deep medium textured soils	dm	Hygric - subhygric	kw
ESSF	mv4		BP	2,3ab	Bluejoint - Cow parsnip avalanche track	Blue joint, bluebells, cow parsnip, white geranium, stinging nettle, tall larkspur, meadowrue, Canada violet, wild strawberry, trailing raspberry. Willow dominated phase also recognized with the same herbaceous understory	variable	Below 1200m Well to imperfectly drained, significant slopes, deep medium textured soils	dm	Subhygric - hygric	kw
ESSF	mv4		SD	2	Sedge - Dwarf willow moist meadow	sedges, herbs , grasses and dwarf shrubs including dwarf salix and aven species	variable	Mostly above 1900m, level, lower to upper meso slopes, medium textured soil	dmj	Mesic - subhygric	cfsvkw
ESSF	mv4		MW	2,3ab	Water sedge - Fen moss fen	Slender sedge, water sedge or beaked sedge	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		SE	2,3ab	Sedge - Asphodel fen	carex, tuft clubrush	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		WE	3ab,3b	Scrub birch - Willow fen edge	Stunted spruce, willow, Labrador tea	O	depression, organic	pjd	hydric	n/a

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
ESSF	mv4		FS	2	Slender sedge - Fen moss fen	Carex	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		FB	2,3ab	Scrub birch - Sedge fen	Birch willow carex	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		WP	2,3ab,3b	Water sedge - Bristle stalked sedge, perched fen	Sedges, willow, bog birch, horsetail	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		LG	2,3ab,3b	Labrador tea - Glow moss, sloping fen	Sedges, willow, bog birch, Labrador tea, horsetail	O	depression, organic	pd	hydric	n/a
ESSF	mv4		ME	2	Horsetail - Giant water moss, oxbow marsh	Swamp horsetail	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		RS	2	Rush - Sedge marsh	Common great bulrush	O	depression, organic	pjd	hydric	n/a
ESSF	mv4		KR	2	Kalm's lobelia - Rush marl flats	Kalm's lobelia, sedges, rushes	O	depression, organic	pjd	hydric	n/a
All			BA	1a	barren	variable invader species chiefly annual forbs	variable				w,k
All			CL	1a	cliff	variable but includes mosses and lichens	R	very steep rock scarps		very xeric	w,k
All			ES	1a	exposed soil	variable	variable				c,f,m
All			LB	1a	lava bed	variable, usually high lichen	R	recent lava flows		xeric-very xeric	w,k
All			MU	1a	mudflat sediment	pioneer herbs, possible sparse willow	F	on margin of active streams or delta	a	hygric-hydric	
All			RG	1a	rock glacier	dominated by lichen and mosses	C	slow or rapid mass movement	c	xeric-very xeric	
All			RP	N/A	road surface	pioneer herbs dominate	variable	level to gentle slopes	j	mesic or drier	
All			UR	N/A	urban/suburban	variable	variable	usually not on steep slopes		mesic or drier	
All			BE	1a	beach	variable	L,F	mostly margin of lake or pond	a,j	mesic-suhydric	
All			CB	1a	cutbank	variable	C	unconsolidated materials- steep		mesic-xeric	c,f,m,k,w
All			GB	1a	gravel bar	pioneer herbs, possible sparse willow	F	active watercourses	c,a	subhygric-hygric	
All			GP	1a	gravel pit	variable	F	fluvial or glacio-fluvial materials	c,j,d	sumesic-very xeric	
All			OW	N/A	shallow open water	N/A	N/A	shallow pond			
All			RI	N/A	river	N/A	N/A	not include non-mapable stream			
All			RU	1a	rubble	variable, often dominated by moss or lichen	C	colluvium usually moderate-steep	c	mesic-very xeric	k,w,

ZONE	SUBZONE / VARIANT	SITE SERIES NUMBER	SITE SERIES SYMBOL	STRUCTURAL STAGE(S)	SITE SERIES NAME	VEG DESCRIPTION	TERRAIN DESCRIPTION	ASSUMED TYPICAL SITUATION	ASSUMED SITE MODIFIERS	TYPICAL SOIL MOISTURE REGIME	MAPPED SITE MODIFIERS
All			TA	1a	talus	variable	C	usually moderate slope or greater	c		k,w,s,d
All			BF	1a	blockfields, blockslopes	variable, usually high lichen	M,C	often at high elevation	c	xeric-very xeric	k,w
All			LA	N/A	lake	N/A	N/A	lake			
All			MS	1a	rubbly mine spoils	variable	A		c	mesic-very xeric	k,w
All			PD	N/A	pond	N/A	N/A	pond			
All			RE	N/A	reservoir	N/A	N/A	man made pond or lake			
All			RO	1a	rock outcrop	variable	R	normally steep to very steep		xeric-very xeric	w,k
All			TS	1a	mine tailings	variable	A		c	mesic-very xeric	w,k

APPENDIX B: WINTER WILDLIFE SURVEY

GENERAL

Helicopter Flight: March 6, 1997. (0815-1700hrs.) in Bell Ranger
Northern Mountain Helicopters
Pilot: Jason Shaw
Observers: Mark Taylor and Tim Janes
Weather: Variable from light snow to clear and sunshine. Visibility as low as half a mile to more than five miles. Foggy in places. Wind light to still. Temperature around 10 to -15C.

FLIGHT DESCRIPTION

The flight originated at Mackenzie airport at approximately 0815. The flying time to Swannell was roughly 45min. The survey for Rocky Mountain Elk began in the vicinity of Swannell at approximately 08:50. Information obtained from Mari Woods and Fraser Corbould on March 5, 1997, indicated the best place to find the elk would be on the Southwest facing slopes in the old burn just northwest of Swannell camp. Repeated searching of this area yielded approximately 30 moose, but no elk. The search continued for about an hour encompassing the surrounding area.

After refueling at Swannell camp at approximately 11:00, the search continued to the Russel range of mountains. Mari Woods had informed us that the Russell range was good winter habitat for mountain goat and Stone's sheep. The literature review conducted indicated that southwest facing slopes with adjacent cliff escape terrain was preferred by mountain goats and southwest facing slopes and windswept ridges was preferred by Stone sheep. The search of the Russel range began just south east of Ravenal peak. The survey progressed to the west side of Ravenal peak and continued north up the Russel range. In total 11 stone sheep and 24 mountain goats were observed in the Russell Range. The stone sheep and the mountain goats were observed in the habitats that the literature had suggested. It was observed that the upper ESSF and subalpine habitats were being utilized by both mountain goat and Stone's sheep. When the mountain goats were not close to a cliff one of the escape techniques that was observed, was that they used trees as cover (Photo). The mountain goats were seen moving though deep snow to get to reach cliffs. One mountain goat was observed using a avalanche chute to move between the lower subalpine to the alpine. A good portion of the mountain goats were observed in and around the tree line where the tree line interdigitated into the subalpine. After refueling at Finbow camp at approximately 12:30, the search moved to the east side of the Trench up the Akie River.

Although the scenery was spectacular, very little wildlife or tracks were observed. Caribou were observed in the alpine on a west facing windswept ridge (Photo) as the literature review and Mari Woods had suggested. Many cratering sites were observed around the caribou on the ridge. The flight up the Akie had taken us to many such habitats but with no further results. One mountain goat was observed in the Peska drainage on a southwest facing slope high in the alpine. Some tracks were observed in the alpine and subalpine of the Peska drainage, but not half as many as were observed in the Russell range. We flew down the Findlay trench on the way back to the Swannell camp. Three caribou were observed in the middle of a frozen lake (Photo). The lake was very small and was adjacent to Lodgepole pine forest. The helicopter landed at Swannell camp at 15:15 for fuel. The survey was officially completed at that time. Snow depths in the Findlay trench at Swannell camp were approximately 60-70cm (this was not estimated).

WILDLIFE

The actual numbers of wildlife observed during the flight are recorded in Table 1.

Moose
Moose were very common in the valley bottom. Many were bedded down in the snow, few were perturbed by the helicopter. Snow was deep for the most part, up to their elbows (Photo). Large numbers of tracks were common in the valley bottoms.

Elk
We searched for elk in the major valley bottoms and on south facing slopes and in spite of a total of more than two hours searching were unsuccessful.

Stone's Sheep
All the sheep which we encountered were on the Russel Range. We searched the alpine and subalpine areas and sheep were associated with windswept ridges where the snow was less deep and crusted. Shrubs and a few grasses were observed. Many of the sheep were paired with a ram and ewe (photos), though one group of four sheep was seen.

Mountain Goat
All the mountain goat observed were in the alpine and subalpine region and mostly in the former. They were primarily in areas of very steep terrain and in some cases in relatively deep snow (Photo). One group was found in the subalpine area among subalpine fir (Photo) in which they hid while others attempt to escape by climbing upwards in avalanche chutes or hiding against rock faces.

Woodland Caribou
Two groups of caribou were observed, one group of six in the upper Akie watershed (photo)(3 female and 3 yearlings) and three were observed in the Valley bottom of the Trench on a lake (photo).

Other Sightings
Few other animals were noticed but included: ptarmigan (1), ravens (2), coyote (1). A single kill was noted on the Findlay River on the flight south from the study area.

APPENDIX C: RATINGS TABLE

(trat_aki.csv)

APPENDIX D: DETAILED RATING METHODOLOGY

This Appendix describes in detail how the ratings tables and the polygon ratings were generated. Screen captures and other supporting materials are used to illustrate the process. For these illustrations, moose is used as an example, however, the methodology is similar for all species.

Four basic stages were involved:

A. Generation of the Ratings Tables,
B. Generation of the Base Polygon Ratings,
C. Spatial Adjustments of Polygon Ratings (if required), and
D. Joining, Exporting and Viewing the Complete Set of Polygon Ratings.

Stages A, B, and D were all completed in Microsoft Access 97. Stage C, the spatial adjustments, were done using Arc Macro Language (AML) in Arc/Info GIS.

All of the digital files are contained on the accompanying CD-ROM (included as Appendix F). The AMLs for each species are in text format and can be viewed in any word processor. Most of the remaining files are in Microsoft Access format and must be opened in Microsoft Access 97 or later. A working knowledge of Access or another relational database program is needed in order to understand and run the models.

Wherever relevant, specific filenames for files contained in Appendix F are listed in parentheses.

Figure D.1 shows a schematic of the MS Access files, tables and queries used to generate the ratings table and polygon ratings. A separate model was created for each species (e.g. filename "M-ALAL-model.mdb").

A. Generation of the Ratings Tables

1. A list of all ecosystem units was generated from the TEM polygon data (filename "Legend.mdb"). This list was then imported into the ratings table model for each species.

2. Separate lists of all Ecosections, BGC subzone variants, site series, structural stages and stand compositions were generated. Downgrading scores were assigned to each value of each attribute. These scores are listed in each of the written models in this document.

Note: Decimals (".") were inserted in place of null values in all tables. MS Access does not allow null values in primary keys.

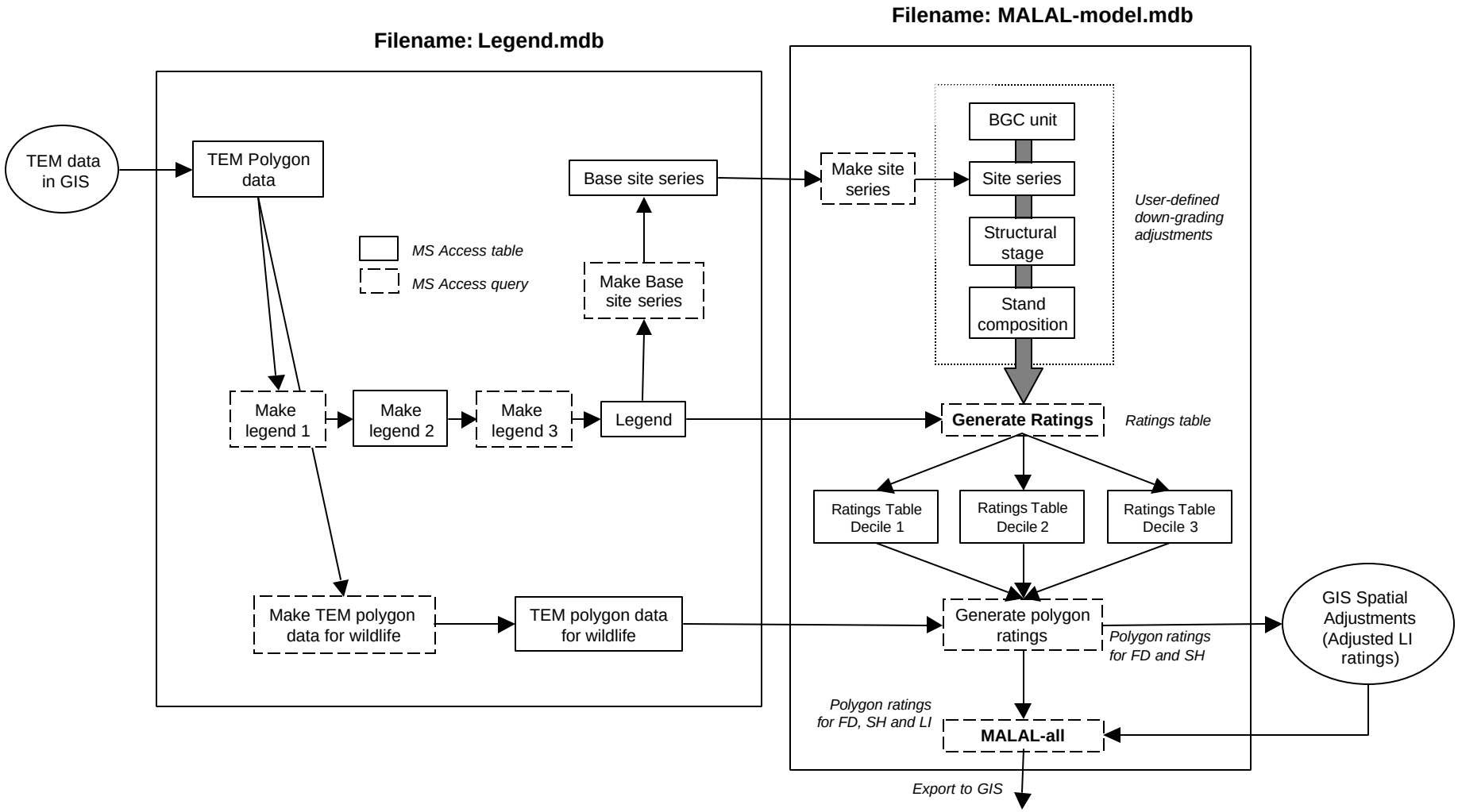
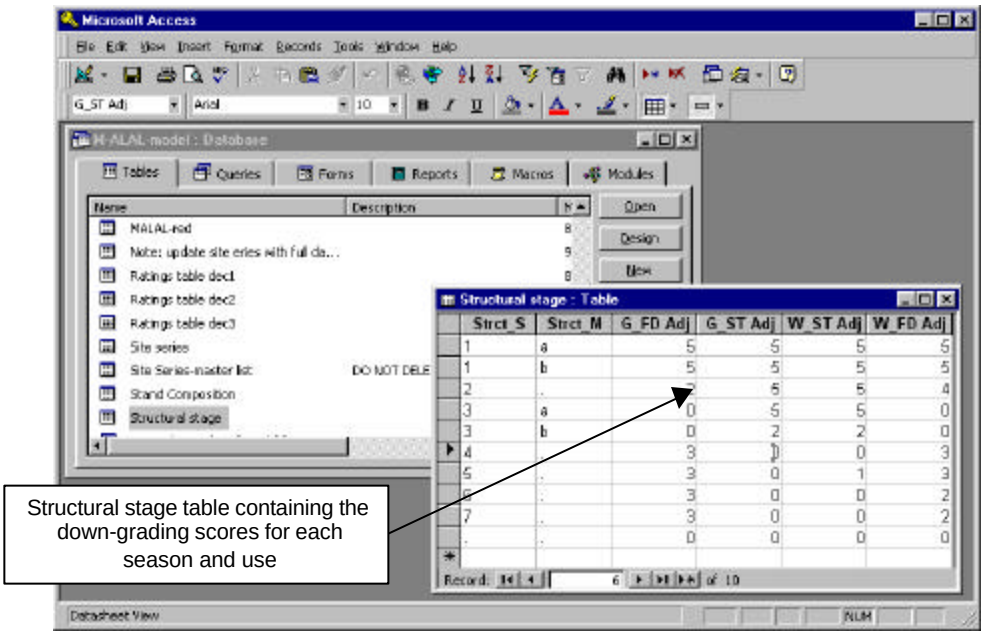
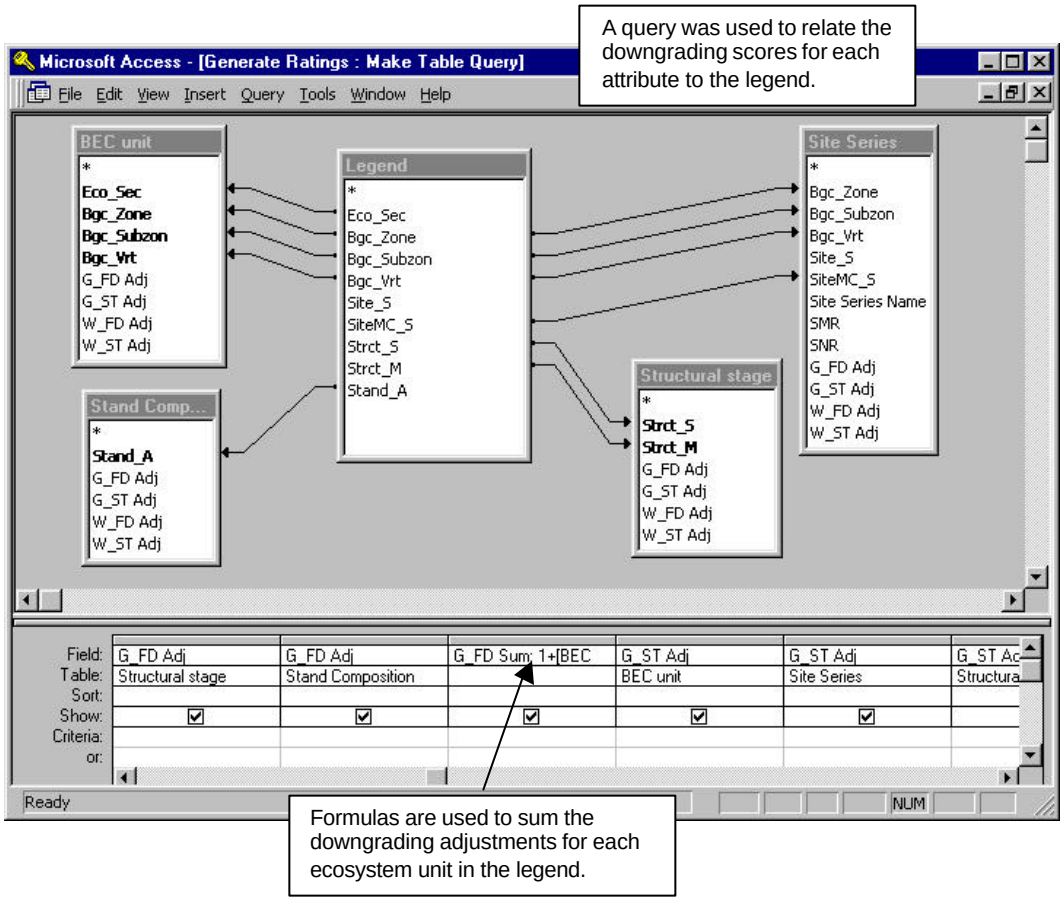


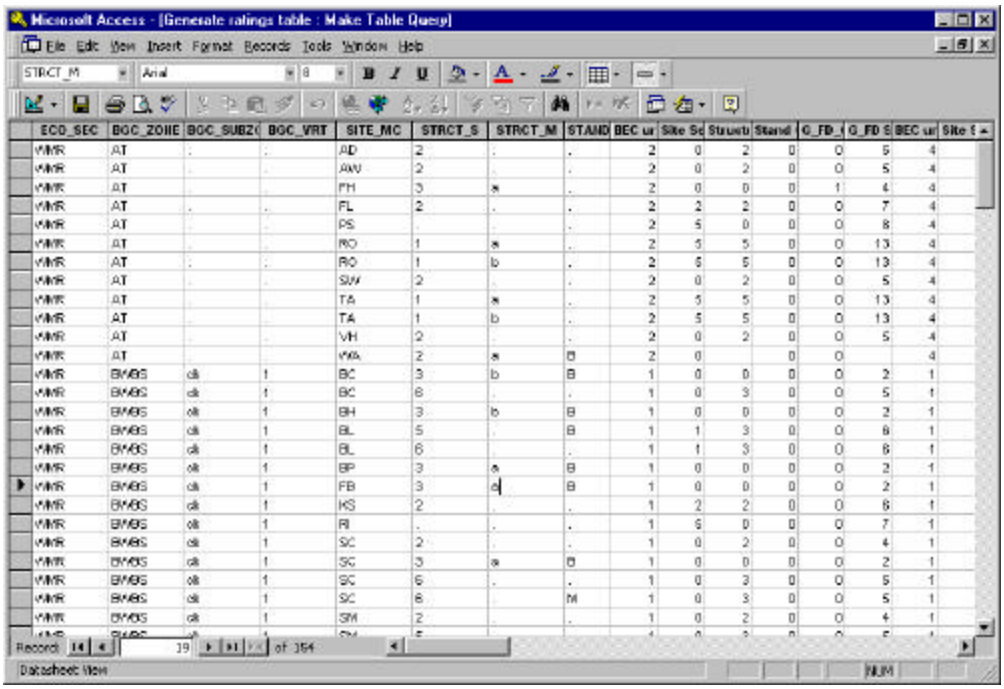
Figure D.1 A schematic diagram showing the process of generating the ratings table and the polygon ratings. Each box is a separate MS Access table or query. The circles represent components of the process that are completed in the GIS. Moose (M-ALAL) has been used in this example but there is a separate "model" file for each species. The process is identical for all 11 species.



3. A query was then built that relates the down-grading scores to the legend and then sums these scores over all attribute of an ecosystem unit.



4. When the query was run, ratings were generated for each ecosystem unit.



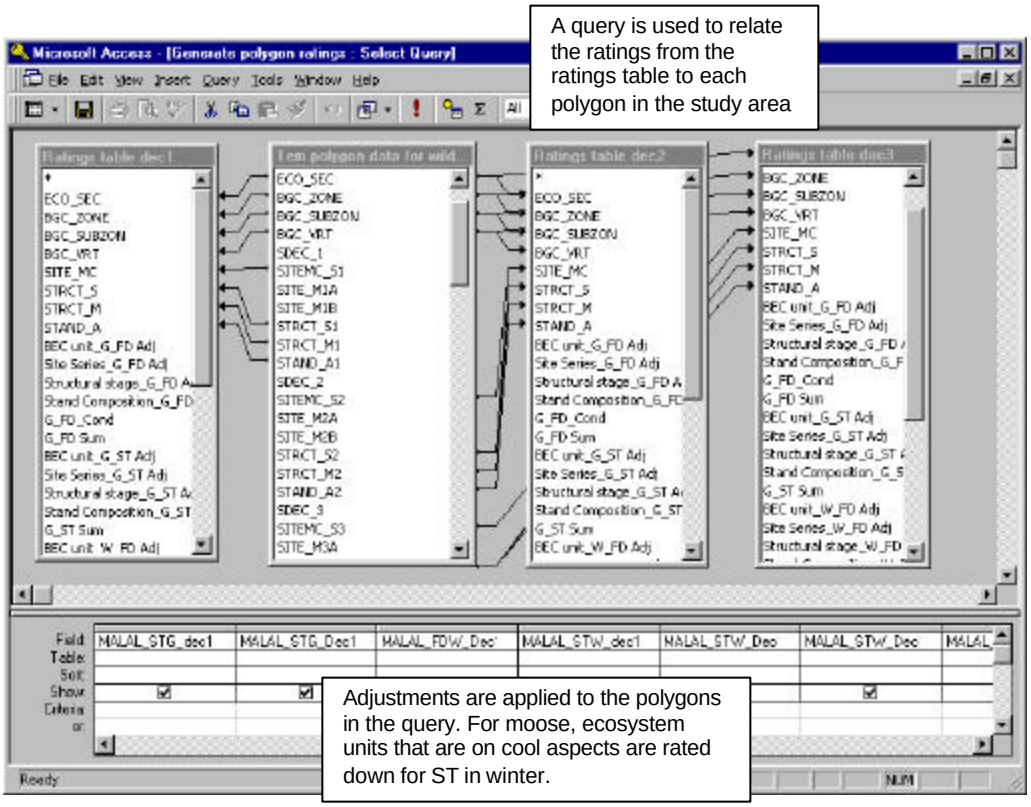
As an example, consider the generation of the ratings for moose for a single ecosystem unit:

Eco_Sec	Bgc_Zone	Bgc_Subzon	Bgc_Vrt	Site_S	SiteMC_S	Strct_S	Strct_M	Stand_A	BEC unit.G_FD Adj	Site Series.G_FD Adj	Structural stage.G_FD Adj	Stand Composition.G_FD Adj	G_FD Sum	BEC unit.G_ST Adj	Site Series.G_ST Adj	Structural stage.G_ST Adj	Stand Composition.G_ST Adj	G_ST Sum	BEC unit.W_FD Adj	Site Series.W_FD Adj	Structural stage.W_FD Adj	Stand Composition.W_FD Adj	W_FD Sum	BEC unit.W_ST Adj	Site Series.W_ST Adj	Structural stage.W_ST Adj	Stand Composition.W_ST Adj	W_ST Sum	MALAL_FDG	MALAL_STG	MALAL_FDW	MALAL_STW
CAR	SWB	mk	.	01	SB	3	a	M	0	0	0	0	1	0	0	5	0	6	1	0	0	0	2	1	0	5	0	7	1	6	2	6
Ecosystem unit									G_FD scores					G_ST scores					W_FD scores					W_ST scores					Final			

B. Generation of Base Polygon Ratings

1. The TEM polygon data was first prepared for use in the polygon ratings models. Decimals (".") were inserted in place of null values for relevant attributes. This was completed in the file "Legend.mdb".

2. A new query was created that assigns ratings to each decile in each polygon. Ratings were then assigned to each ecosystem unit. Adjustments were applied to the ecosystem unit ratings. The overall polygon rating was then calculated.



3. The polygon ratings were then exported for use in the GIS for the spatial adjustments.

C. Spatial Adjustments of Polygon Ratings (If Required)

1. Spatial adjustments were completed for seven of the eleven species. Adjustments were not required for marten, fisher, wolverine and caribou.

2. For all of the spatially adjusted species, a model was written in AML to determine food and security/thermal ratings in adjacent polygons. Both the polygon ratings and the ratings in adjacent polygons were used to generate the living ratings. The specific algorithm to determine the living rating is described in each of the species-habitat models.

3. The detailed procedure is as follows:

   i. Import the .csv file into INFO using the DEFINE and ADD FROM commands

   ii. Joinitem the imported INFO file and the coverage.pat using the POLY_NBR attribute.

iii. Run the species ARC/INFO AML (<species name>.aml) to initialize the proper species code variable

iv. Run the species pre-living AML to acquire the adjusted spatial ratings for the seasons living ratings. For example, to execute the program for the grizzly, the program, grizzlypreliv.aml would be carried out.

v. The program species living AML is used to calculate the overall living rating for the species. For example, to execute the overall living program for the grizzly, grizzlyliv.aml would be used.

vi. Unload the .pat. Include the attributes poly_nbr, season living ratings, and the overall living rating. This table will be joined to the spatial data in ArcView to view the results.

D. Joining and Exporting of the Complete Set of Polygon Ratings

1. After the spatial adjustments were completed, the living ratings were joined with the seasonal food and security ratings to produce the complete set of polygon ratings. This was then exported for use in Arc/Info to create the maps.

2. To assess the accuracy of the models, the polygon ratings were viewed in ArcView before the final maps were generated. Adjustments to the models could then be made.