TERRESTRIAL ECOSYSTEM MAPPING AND WILDLIFE INTERPRETATIONS FOR THE DUNEDIN STUDY AREA

by:

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for:

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1.0 INTRODUCTION

1.1 Objectives

The project objectives are to classify, map (at a scale of 1:50,000) and describe the terrestrial ecosystems of the Dunedin study area, and to interpret them with respect to their wildlife habitat values. This information is intended to provide a basis for future ecosystem and wildlife management.

1.2 Physical Description of Study Area

The Dunedin study area is shown in Figure 1. Lying east of the Rocky Mountains in the northeast corner of B.C., the study area consists of the Dunedin River watershed, flanked on the west by the Toad River watershed, to the east by the Fort Nelson River watershed, and to the southeast by the Kledo Creek watershed. The Dunedin River watershed includes the drainages of its tributaries: Torpid Creek, Odayin Creek, McClennan Creek, and Snake Creek. To the south, the study area extends slightly beyond the watershed boundary and includes the portions of the drainages of One Fifteen Creek, One Thirteen Creek, and Mill Creek north of the Alaska Highway and the Stone Mountain Provincial Park boundary.

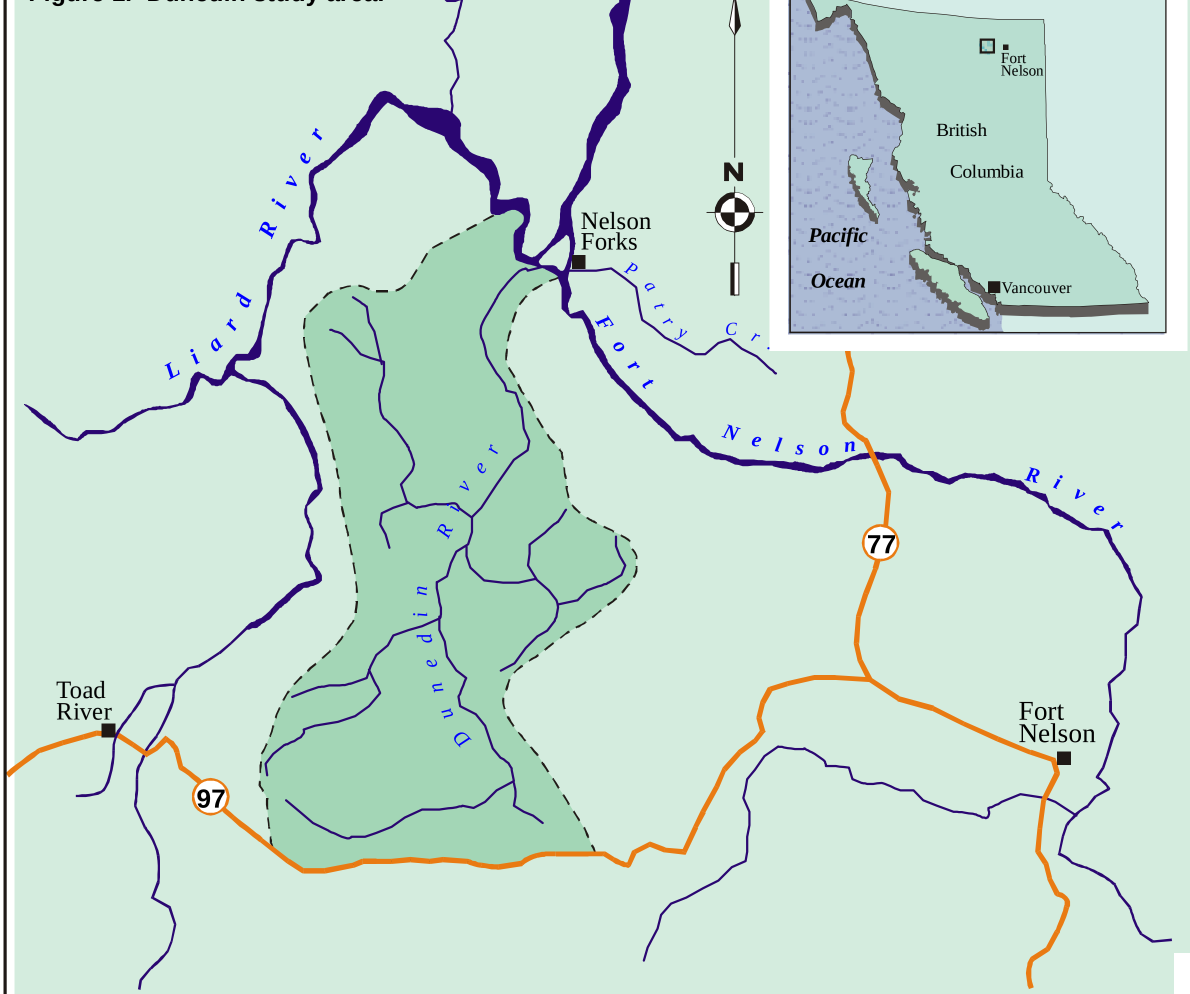

Figure 1. Dunedin study area.

1.2.1 Geology and Terrain

Over half of the study area is part of the Fort Nelson Lowlands (Holland, 1976) and lies below 610 m above sea level (a.s.l.). The lowest part is the mouth of the Dunedin River at approximately 250 m a.s.l. In the southern half of the study area, the Alberta Plateau rims the west and east sides of the Dunedin Valley up to 1,210 m a.s.l. The plateau and lowlands are underlain by Cretaceous marine sandstones and shales. This bedrock is visible in the canyon on the Dunedin River and in the Odayin Valley. The bedrock is horizontally bedded or dips gently to the east. The dipped beds give rise to the asymmetrical ridges and valleys with steeper west-facing slopes and gently sloping east-facing slopes.

A small portion of the study area (less than 20%) lies in the Rocky Mountain Foothills (Holland, 1976). Located in the southwest corner of the study area, the foothills have greater relief starting at roughly 1,200 m a.s.l. and rising to a height of 2,105 m a.s.l. Paleozoic formations in the foothills have been thrust over younger Mesozoic formations. The grey paleozoic limestone is easily visible in Stone Mountain and neighbouring peaks. Traveling east from Stone Mountain, the topography becomes more subdued in the Mesozoic formations of calcareous sandstones, shales, and siltstone (Taylor, 1971) where structural deformation by folding and faulting was less intense.

Glaciers moved across the study area from two directions. Cordilleran ice came from the west and left behind medium-textured, stony, calcareous till often less than 3 m thick as it retreated. Cordilleran till is found in the mountainous southwest corner of the study area. Keewatin ice advanced from the northeast and left behind fine-textured till (silty clay loam and silt loam) with very few coarse fragments. This till covers much of the lowland portions of the study area.

Fine-textured glaciolacustrine deposits mark locations of ice-dammed lakes while coarser glaciofluvial deposits mark old meltwater channels. Fluvial deposits are limited in extent and range from medium to coarse textured. Where the foothills meet the lowlands, the rivers deposit their coarser gravels as gradients lessen. Colluvial deposits are common in the foothills. They are also commonly found in the Odayin Valley at the base of escarpments.

1.2.2 Soils

Luvisols are the most common soil type in the Dunedin study area and form on the most common surficial material – fine textured till from the Keewatin Ice Sheet. Fine soil textures, lack of coarse fragments, and gentle slope gradients lead to poor drainage; hence the Luvisols were often found to be gleyed. Luvisols can be anticipated on lacustrine and glaciolacustrine deposits as well.

Regosols are found along the river floodplains (cumulic regosols) and at high elevations in the alpine. In the alpine, cryoturbation often mixes soil particles with the parent material (often local bedrock) to yield an AC horizon sequence.

Organic soils (Mesisols and Fibrisols) and layers of saturated organic material (less than 60 cm deep) over mineral soils are common in relatively flat to depressional areas of the lowland portion of the study area. They occur in areas of poor to very poor drainage.

The study area lies within the zone of discontinuous permafrost (Valentine *et al.,* 1978), and Cryosolic soils were sometimes encountered in bogs and on north-facing subalpine slopes.

1.3 Vegetation

The vegetation of the study area is dominated by a patchwork of slow-growing forests, deciduous shrubs, and wetlands of varying ages and successional stages. Black spruce is dominant in mixture with a variety of species including trembling aspen, white spruce, subalpine fir, lodgepole pine, paper birch, and balsam poplar. At higher elevations in the southwestern portion of the study area, intermittent white spruce and subalpine fir woodland and willow and birch scrub develop. The highest elevations are dominated by alpine meadows and unvegetated cliffs and rubble.

1.4 Wildlife

The cold winters and short growing seasons that prevail in the northern extremes of the province significantly limit the range of wildlife species that can occur. Consequently within the study area, reptiles are absent and only a few species of amphibians occur this far north. Nevertheless, the study area supports some important wildlife populations, especially of some of the larger mammals. Situated around the juncture of the Rocky Mountain foothills and the Fort Nelson Lowlands, the study area encompasses considerable habitat diversity, which in turn supports a relatively broad range of animal species for the latitude. Notable populations include herds of woodland caribou and Stone's sheep in the southern, more mountainous portions of the area. Small populations of Rocky Mountain elk, mule deer, and grizzly bears also occur here. The BWBS dominated plateau area supports more moose, small numbers of mule deer, and possibly low numbers of woodland caribou.

2.0 METHODOLOGY

The following sections describe the methods used in conducting the bioterrain and ecosystem mapping processes and discuss the associated limitations. For ease of reference, methods applied in developing wildlife interpretations, together with a discussion of limitations, are presented in section 6.0 of this report immediately preceding the species-habitat models.

2.1 Data Sources and Background Information

Black and white aerial photographs (approximately 1:63,000 scale) taken in 1986 and 1987 were used to delineate and interpret ecosystem and bioterrain polygons (aerial photograph numbers listed in Appendix 3). BCGS 1:20,000 digital data plotted on an NTS 1:50,000 grid was used as a base for creating the following map sheets: 94N.104, 105, 109, 110, 114, 115; 94O.101; 94K.118, 119, 120, 123, 124, 125; 94J.116. Hugh Hamilton Ltd. compiled aspect maps in order to distinguish significant slopes and aspects. Forest cover maps (Slocan Forest Products Ltd.) were used for mapping the Boreal White and Black Spruce (BWBS) zone, however they were not available for 94K mapsheets.

2.1.1 Vegetation

The ecosystems of the study area are described in the Prince George Forest Region guides (DeLong *et al.,* 1990; MacKinnon *et al.,* 1990). The ecosystem classification of southeast Yukon also describes many of the vegetation types that occur within the Dunedin study area (Zoladeski and Cowell, 1996). The Alberta Vegetation Inventory provides a useful reference (Nesby, 1997) especially for its classification and aerial photographs of boreal wetland types. Studies of fire-ecological relationships within the Fort Nelson T.S.A. are very helpful in interpreting ecosystems of that area (Parminter, 1983).

2.1.2 Terrain/Soils

Soils, surficial geology, and landforms of the Liard Hydro Project study area (which included a portion of the study area) are discussed in depth in Thurber Consultants Ltd. (1981). Bedrock geology for most of the study area is illustrated in Taylor (1971).

2.2 Field Work and Personnel

Table 1. Field Work Personnel and Areas of Expertise

Team Member	Expertise	Dates
Gill Radcliffe	Wildlife/vegetation	August 14-17, 1997
Jan Teversham	Vegetation	August 13-19, 1997
Gordon Butt	Soils/bioterrain	August 14-17, 1997
Ksenia Barton	Vegetation	July 21-29, August 11-19, 1997
Linda Veach	Wildlife	July 21-29, August 11-19, 1997
Pamela Williams	Soils/bioterrain	July 21-29, August 11-19, 1997
Stephan Kesting	Vegetation	July 21-29, August 11-19, 1997
Derrick Marven	Wildlife/birds	July 21-29, 1997
Jason Hindson	Soils/bioterrain	August 11-19, 1997
Julie Williams	Vegetation	August 11-19, 1997

On June 26, 1997, Jan Teversham and Gill Radcliffe carried out a reconnaissance flight of the study area. Fieldwork for mapping and wildlife interpretations was carried out in two field trips. The first field trip covered the northern portion of the study area, July 21 to 29, 1997, and was based from Tackama Camp. The second field trip, August 11 to 19, 1997, covered the southern portion of the study area and was based from Toad River. The field crews were made up of personnel with various area of expertise (summarized in Table 1). Most field access was by helicopter with a small portion of the study area accessible by truck along the Alaska Highway.

2.2.1 Plant Species Identification

Plants were identified in the field using field guides (MacKinnon *et al.,* 1992; Johnson *et al.,* 1995). Difficult plants were pressed and keyed out using the provincial botanical keys (Douglas *et al.,* 1989, 1990, 1991, and 1994). Where identifications could not be made with confidence, voucher specimens were sent for expert identification. Terry MacIntosh identified vascular plants and bryophytes, Chris Brayshaw identified willows, and Trevor Goward identified lichens. Willows could not always be identified to species due to lack of catkins on most specimens.

2.3 Bioterrain Mapping

The terrain mapping methodology as outlined in *Guidelines and Standards to Terrain Mapping in B.C*. (Resources Inventory Committee (RIC), 1996) was followed as closely as possible. Time constraints did not permit full pre-typing of the aerial photographs before fieldwork. Labeling of bioterrain units followed Howes and Kenk (1997) with one enhancement to distinguish between continental till and cordilleran till. Drainage was mapped using drainage classes described in *Field Manual for Describing Terrestrial Ecosystems* (B.C. MOELP and B.C. MOF, 1998).

2.4 Ecosystem Mapping

Classification and mapping follow the methodology documented in *Standard for Terrestrial Ecosystem Mapping for British Columbia* (Ecosystems Working Group, 1998) and in draft versions of that document (Ecosystems Working Group, 1995; Cadrin *et al.,* 1996).

Bioterrain polygons were initially delineated on the aerial photographs. These bioterrain polygons were then further subdivided along vegetation boundaries including boundaries between different successional stages arising from natural disturbances such as fire and floodplain processes.

Ecosystem units drawn from various sources have been assigned two letter symbols. Table 5 in section 3.3 summarizes the mapped ecosystem units, their sources, and their structural stages and site modifiers. Mapping of site modifiers for atypical conditions follow the recent standard (Ecosystems Working Group, 1998). Aspect modifiers are mapped where ecosystem units that typically occur on gentle slopes are present on significant slopes. Aspect maps were used to distinguish significant slopes because the 1:63,000 scale aerial photographs, seen in stereo, exaggerate the apparent gradient of slopes. The definitions for soil texture modifiers are drawn from the standard available when mapping began (Cadrin *et al.,* 1996).

Structural stages describe the vegetation structure and successional status by a seven level system (Ecosystems Working Group, 1998). Aerial photograph interpretation, rather than forest cover data, was used to map structural stages because forest cover mapping was only available for a portion of the study area (94N mapsheets). Forest cover data was used, however, to distinguish between structural stages 6 and 7 within the Boreal White and Black

Spruce (BWBS). Stand age was used to identify old forests because older stands in the boreal forest rarely develop the typical structural characteristics of old forests (Craig DeLong, Prince George Forest Region, *pers. comm.*). Structural stage 7 was mapped in the BWBS where forest cover maps indicate pure or mixed white spruce stands that are at least 140 years old. Structural stage 7 stands have not been mapped within the BWBS areas covered by the 94K mapsheets (lacking forest cover data) because those areas have younger stands due to more recent and widespread fire history.

In the Spruce Willow Birch (SWB) zone, the age criterion for old forests is 250 years. Woodlands in that zone were mapped as structural stages 3b, 5, and 6. Lack of forest cover data and structural characteristics made it difficult to identify structural stage 7 stands. Relatively frequent fire and fungal disease disturbance may prevent forest succession to structural stage 7 in the SWB zone. Woodland succession progresses from structural stage 3 to structural stage 3b or 5. The structural characteristics of the pole/sapling stage do not develop in the SWB zone because tree canopies tend to remain open and structurally diverse.

Structural stage 3 represents shrub-dominated sites that are expected to succeed to forest or woodland. The vegetation of this structural stage ranges from pioneer deciduous shrub to regenerating stands with trees that are less than 10 m tall. Structural stage 3a has been mapped where the site is maintained in a low shrub stage due to edaphic (shrubby fens) or climatic conditions (subalpine scrub). Structural stage 3b has been mapped where the unit is maintained in a tall shrub stage. The tall shrub structural stage usually identifies coniferous woodlands with stunted trees (less than 10 m tall) due to edaphic conditions (treed bogs) or climatic conditions (stunted subalpine woodlands). Structural stage 3b is also mapped for tall disclimax willow thickets.

Within the polygon attribute database, stand composition modifiers have been added to differentiate between coniferous, mixed, or broadleaf stands (C, M, or B). Stand composition modifiers have not been specified for regenerating stands (structural stage 3) because stand composition can vary as the stand regenerates.

Notes on mapping procedures that are specific to ecosystem units are included in the unit descriptions.

2.5 Ecosystem Map Reliability and Data Limitations

2.5.1 Survey Intensity

Field sampling resulted in 63 ecosystem plots, 219 ground inspections, and 756 visual plots (mostly done from a hovering helicopter) for a total of 1,038 plots. The survey intensity (number of plots/number of polygons) was 28%, exceeding the standard for survey intensity level 4 specifying 15% to 25% polygon visitation (Ecosystems Working Group, 1998).

2.5.2 Biogeoclimatic Unit Mapping

Table 4 summarizes the elevational boundaries used in mapping the biogeoclimatic (BGC) units of the study area. Mapping follows that of the provincial BGC maps where field verification was not possible for this project (B.C. Ministry of Forests, 1995). Little documentation is available on distinguishing the BGC units. The topography of the study area did not permit field transects on zonal slopes to confirm the elevation of the boundary between the Boreal White and Black Spruce (BWBS) zone and the Spruce Willow Birch (SWB) zone. The elevation of the boundary between the Kledo Wet Cool (wk3) and Fort Nelson Moist Warm (mw2) subzones of the BWBS zone was not confirmed due to lack of helicopter landing spots. A small area of Moist Cool (mk) SWB along the eastern study area boundary was not checked because poor weather repeatedly prevented landing of the helicopter there. Topographically, though, it is similar to areas of mapped BWBSwk3.

Mapping of the Moist Cool Scrub SWB (SWBmks) and of the Alpine Tundra (AT) was complicated by difficulties in aerial photograph interpretation discussed in the following section.

2.5.3 Aerial Photograph Interpretation of Ecosystem Units

Aerial photograph interpretation was used in part to determine the SWBmk/mks and SWBmks/AT boundaries. Significant disturbance due to fire at those elevations made it difficult to generalize the upper limits of tree and low tree/krummholz growth from aerial photograph interpretation. As well, changes in vegetation associated with "visual" BGC boundaries were often obscured by colluvial action resulting in areas of unvegetated rubble at high elevations. Finally, the trellis pattern of drainage in the mountainous portion of the study area resulted in isolated polygons of AT and SWBmks, increasing the difficulty of generalizing elevational boundaries along slopes.

Tree species are difficult to identify on the 1:63,000 aerial photographs; large scale photographs (1:15,000) are recommended for such purposes (Keser, 1990). The forest cover maps were heavily relied on for ecosystem mapping of the BWBS zone. Mapping reliability of the BWBSmw2 on the 94K mapsheets is lower than elsewhere in the study area due to lack of forest cover mapping.

In interpreting ecosystem units from the aerial photographs, gray tone variation was one element used to distinguish units. This was complicated by the poor technical quality of the photographs, resulting in significant variation in overall tone and contrast from photograph to photograph.

Within the study area, there are large areas that have been recently burned. The ecosystem units of these areas are probably mapped less reliably because canopy species and appearance cannot be used in ecosystem identification. This caution applies to the SWB zone in particular where the ecosystem classification is in preliminary stages.

Submesic and mesic Black spruce - Lingonberry (BL) stands regenerating from fires are difficult to distinguish from the moister Black spruce - Feathermoss (BB) forest and the Black spruce - Sphagnum (BS) and Black spruce - Willow (BW) wooded bogs on aerial photographs. All have open, low tree cover with light-coloured moss showing through. The forest cover maps did not distinguish between burned BL stands and wetter forest types, labeling them all as non-productive black spruce stands. Some forested bogs (BB, BS) have a mottled appearance on air photos due to the presence of collapse scars caused by local subsidence of permafrost (National Wetlands Working Group, 1988).

3.0 BIOGEOCLIMATIC ECOSYSTEM CLASSIFICATION

3.1 Ecoregion Units

The Ecoregion Classification system was developed to stratify British Columbia into discrete geographical units at five different levels. The two highest levels, Ecodomains and Ecodivisions, are very broad, while the three lowest levels, Ecoprovinces, Ecoregions, and Ecosections, are progressively more detailed in scope and relate segments of the province to one another. They describe areas of similar climate, physiography, hydrology, vegetation, and wildlife potential (Demarchi, 1996).

The Dunedin study area falls within the Polar Ecodomain. Its climate is characterized by low temperatures, severe winters, and small amounts of precipitation (Demarchi, 1996). A major change in topography from upland to mountainous terrain within the study area marks the division between the Sub-Arctic and Sub-Arctic Highlands Ecodivisions. The ecoregion classification of the study area is summarized in Table 2.

Table 2. Ecoregion Classification of the Dunedin Study Area

Ecodivision	Ecoprovince	Ecoregion	Ecosection
Sub-Arctic	Taiga Plains	Muskwa Plateau	Muskwa Plateau
Sub-Arctic Highlands	Northern Boreal Mountains	Northern Canadian Rocky Mountains	Muskwa Foothills

The Muskwa Plateau Ecosection (MUP) is a dissected upland area that rises above the Fort Nelson Lowland to the east. The Muskwa Foothills Ecosection (MUF) is an area of subdued mountains that are isolated by wide valleys. This area is in the rain shadow of the Rocky Mountains to the west; it is also more commonly under the influence of cold Arctic air in the winter (Demarchi, 1996).

3.2 Biogeoclimatic Units

The biogeoclimatic (BGC) classification system groups and divides ecosystems according to climate and climax vegetation of typical sites. Table 3 summarizes the BGC classification of the Dunedin study area with associated climate data.

The Boreal White and Black Spruce (BWBS) is a lowland to montane zone characterized by a northern continental climate with long, cold winters and short summers. Poor tree growth reflects the adverse climate, especially the short growing season and cold soil temperatures (DeLong *et al.,* 1990). The Fort Nelson Moist Warm (mw2) subzone covers lowland and undulating terrain. Forest cover varies, but white spruce, trembling aspen, and paper birch forests are usually present on moderately well drained sites. Poor sites are dominated by black spruce and lodgepole pine forests. The Kledo Wet Cool (wk3) subzone occurs along ridgetops and is characterized by lodgepole pine, white spruce, and black spruce forests with black huckleberry in the understorey.

The Spruce Willow Birch (SWB) zone has an interior subalpine climate characterized by long, very cold winters and brief, cool summers. The Moist Cool (mk) subzone occurs at lower elevations of the SWB where intermittent white spruce and subalpine fir woodlands predominate. The Moist Cool Scrub (mks) subzone occurs at higher elevations where willow and scrub birch low shrub is interspersed with grass and sedge-dominated meadows and occasional patches of krummholz (MacKinnon *et al.,* 1990).

The severe climate of the Alpine Tundra (AT) zone is characterized by low growing season temperatures and a very short frost-free period. The AT is treeless and is dominated by dwarf woody plants, sedges, and lichens (MacKinnon *et al.,* 1990).

Table 3. Biogeoclimatic Classification of the Dunedin Study Area and Summary Climate Data
(adapted from DeLong et al. 1990 and MacKinnon et al. 1990)

Zone	Subzone	Variant	Seasonal Precip. May Sept Mean (mm)	Annual Precip. Mean (mm)	Annual Mean Temp.	Annual Snowfall Mean (cm)	Frost-free period Mean (days)
BWBS	mw Moist Warm	2 Fort Nelson	295	460	-1.6	185	105
Boreal White and Black Spruce	wk Wet Cool	3 Kledo					
SWB	mk Moist Cool		350	580	-1.9	270	35
Spruce Willow Birch	mks Moist Cool Scrub						
AT			425	1460	-0.8	1265	50

In general, BGC unit mapping in the Dunedin study area is consistent with provincial mapping (B.C. Ministry of Forests 1995). Elevational boundaries delineating the BGC units were generalized from plot data (Table 4) and refined through aerial photograph interpretation.

Table 4. Elevational Boundaries Used in Mapping BGC Units

BGC Boundary	Elevation (m)		
	warm aspect	cool aspect	level
BWBSmw2/wk3	950	900	900
BWBSmw2/SWBmk	1050	1000	1000
SWBmk/mks	1450	1340	1400
SWBmks/AT	1650	1550	1600

3.3 Ecosystem Units

Within a BGC unit, ecosystem classification is based on variations in climax vegetation due to moisture regime, nutrient regime, or other site characteristics. Map units are made up of two-letter ecosystem unit codes, site modifiers, seral associations, structural stages, and stand composition modifiers (Ecosystems Working Group, 1998). Some ecosystem units described in this report are based on units described elsewhere; others are described here for the first time. Table 5 summarizes ecosystem units used in mapping the Dunedin study area.

Table 5. Ecosystem Units of the Dunedin Study Area

BGC UNIT	CODE	UNIT NAME	SITE SERIES	ECOSYSTEM TYPE	SOURCE	STRUCTURAL STAGES MAPPED	MODIFIERS MAPPED
BWBSmw2	AM	SwAt - Step moss	01	Forest	DeLong *et al.* 1990	3, 4B, 4C, 4M, 5B, 5C, 5M, 6B, 6C, 6M, 7C, 7M	k, w, q, z, y
BWBSmw2	LL	Pl - Lingonberry - Velvet-leaved blueberry	02	Forest	DeLong *et al.* 1990	3bC, 4C	w
BWBSmw2	BK	Sb - Lingonberry - Knight's plume	03	Forest	DeLong *et al.* 1990	3, 4C, 4M, 5B, 5C, 5M	k, w, q, z, s
BWBSmw2	BL	Sb - Lingonberry - Coltsfoot	04	Forest	DeLong *et al.* 1990	3, 3M, 3bC, 4C, 5C, 6C	k, w, s
BWBSmw2	SH	Sw - Currant - Horsetail	05	High bench floodplain forest	DeLong *et al.* 1990	3, 4C, 5M, 6C, 6M, 7C, 7M	a, m
BWBSmw2	SH:pa	Acb - Mountain alder - dogwood	05$	Medium bench floodplain forest	DeLong *et al.* 1990	4B, 5B	a, m
BWBSmw2	SD	Spruce - Devil's club	-	Forest	Dunedin Plots	6M	
BWBSmw2	BB	Sb - Feathermoss	06	Forest	DeLong *et al.* 1990	3, 3bC, 4C, 5C, 6C	p
BWBSmw2	BS	Sb - Cloudberry - Sphagnum	08	Treed bog	DeLong *et al.* 1990	2d, 3aB, 3bC	
BWBSmw2	BW	Sb - Willow	09	Treed bog	DeLong *et al.* 1990	2b, 3bC	p
BWBSmw2	TB	Lt - Buckbean	10	Treed fen	DeLong *et al.* 1990	2a, 3bC	
BWBSmw2	SB	Sandbar willow	-	Shrubby vegetated gravel bar	MacKenzie 1998	3aB	
BWBSmw2	WA	Willow - Alder	-	Shrubby disclimax	Teversham and Veach 1998	3bB	k, w
BWBSmw2	JB	Tall Jacob's ladder - Bluejoint	-	Wet fluvial meadow	Dunedin Plots	3aB, 3bB	
BWBSmw2	SS	Scrub birch - Willow -Water sedge	-	Fen	MacKenzie 1998	2b, 3aB	
BWBSmw2	CL	Cliff	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
BWBSmw2	ES	Exposed soil	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w, q, z
BWBSmw2	GB	Gravel bar	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
BWBSmw2	LA	Lake	-	Unvegetated	Ecosystems Working Group 1998	-	
BWBSmw2	PD	Pond	-	Unvegetated	Ecosystems Working Group 1998	-	
BWBSmw2	RI	River	-	Unvegetated	Ecosystems Working Group 1998	-	
BWBSmw2	RO	Rock outcrop	-	Sparsely vegetated	Ecosystems Working Group 1998	1	w
BWBSmw2	RU	Rubble	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
BWBSmw2	TA	Talus	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
BWBSmw2	SC	*see SWBmk*					
BWBSmw2	SK	*see SWBmk*					

BGC UNIT	CODE	UNIT NAME	SITE SERIES	ECOSYSTEM TYPE	SOURCE	STRUCTURAL STAGES MAPPED	MODIFIERS MAPPED
BWBSmw2	SP	*see SWBmk*					
BWBSmw2	SW	*see SWBmk*					
BWBSwk3	LC	Lodgepole pine - Crowberry	-	Forest	Dunedin Plots	3, 3aC, 3bC, 4C, 5C, 6C	w, k
BWBSwk3	FH	Subalpine fir - Black huckleberry	-	Forest	Dunedin Plots	3, 4C, 5C, 6C	w
BWBSwk3	LB	Lodgepole pine- Bluejoint	-	Forest	Dunedin Plots	5C, 6C	
BWBSwk3	WA	Willow - Alder	-	Shrubby disclimax	Teversham and Veach 1998	3bB	
BWBSwk3	BA	Bog blueberry - Alpine bearberry	-	Vegetated bedrock	Dunedin Plots	3aB	w
BWBSwk3	JB	Tall Jacob's ladder - Bluejoint	-	Meadow	Dunedin Plots	3aB	
BWBSwk3	FL	Fragrant wood fern - Lichen	-	Vegetated talus	Dunedin Plots	2d	
BWBSwk3	CL	Cliff	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
BWBSwk3	RU	Rubble	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
SWBmk`	AM	SwAt - Step moss	01	Forest	DeLong *et al.* 1990	3, 4B, 4C, 4M, 5B, 5C, 5M, 6B, 6C, 6M, 7C, 7M	k, w, q, z, y
SWBmk`	BL	Sb - Lingonberry - Coltsfoot	04	Forest	DeLong *et al.* 1990	3, 3M, 3bC, 4C, 5C, 6C	k, w, s
SWBmk	SB	Unnamed*	-	Woodland	DeLong 1998	6C	w
SWBmk	SK	Unnamed*	-	Woodland	DeLong 1998	3, 3bC, 5C	a, j, w
SWBmk	SW	Unnamed*	-	Woodland	DeLong 1998	3bC, 5B, 6C	w
SWBmk	SL	Unnamed*	-	Woodland	DeLong 1998	3bC, 6C	j
SWBmk	SC	Unnamed*	-	Woodland	DeLong 1998	3bC	j, k, x
SWBmk	SH	Unnamed*	-	Woodland	DeLong 1998	6C	
SWBmk	SP	Spruce - Polargrass	-	Permafrost bog	Dunedin Plots	3aB	k
SWBmk	JB	Tall Jacob's ladder - Bluejoint	-	Wet meadow	Dunedin Plots	3aB	
SWBmk	WS	Willow - Sedge	-	Willow fen	Thompson 1998	3aB	
SWBmk	WY	Willow - Yellow mountain-avens	-	Vegetated gravel bar	Dunedin Plots	3aB	
SWBmk	CL	Cliff	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
SWBmk	GB	Gravel bar	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
SWBmk	PD	Pond	-	Unvegetated	Ecosystems Working Group 1998	-	
SWBmk	RI	River	-	Unvegetated	Ecosystems Working Group 1998	-	
SWBmk	RG	Rock glacier	-	Unvegetated	Ecosystems Working Group 1998	1a	

BGC UNIT	CODE	UNIT NAME	SITE SERIES	ECOSYSTEM TYPE	SOURCE	STRUCTURAL STAGES MAPPED	MODIFIERS MAPPED
SWBmk	RU	Rubble	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
SWBmk	LA	Lake	-	Unvegetated	Ecosystems Working Group 1998	-	
SWBmk	TA	Talus	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
SWBmk	AW	*see SWBmks*					
SWBmk	MA	*see SWBmks*					
SWBmk	SA	*see SWBmks*					
SWBmks	SA	Scrub birch - Altai fescue	-	Subalpine scrub	Dunedin Plots	3aB	k, w
SWBmks	MA	Entire-leaved mountain-avens - Arctic lupine	-	Subalpine scrub/meadow	Thompson 1998	3aB	k, w
SWBmks	SC	Unnamed*	-	Subalpine krummholz	DeLong 1998	3aM	j
SWBmks	AW	Entire-leaved mountain-avens - Netted willow	-	Subalpine meadow	Thompson 1998	2d	k, w
SWBmks	CL	Cliff	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
SWBmks	GB	Gravel bar	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
SWBmks	PD	Pond	-	Unvegetated	Ecosystems Working Group 1998	-	
SWBmks	RU	Rubble	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
SWBmks	SC	*see SWBmk*					
SWBmks	SK	*see SWBmk*					
AT	ML	Moss campion - Limestone sunshine lichen	-	Alpine meadow	Dunedin Plots	2d	k, w
AT	BF	Blockfield	-	Sparsely vegetated	Ecosystems Working Group 1998	1	
AT	CL	Cliff	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w
AT	RU	Rubble	-	Sparsely vegetated	Ecosystems Working Group 1998	1	k, w

* These units have not yet been assigned official names; contact Regional Ecologist for clarification.

4.0 ECOSYSTEM UNITS

Table 5 summarizes all of the ecosystem units described in this report and lists associated references.

4.1 Sources of Disturbance

The most significant source of disturbance within the study area is fire caused by lightning (Parminter, 1983). Photo 1 shows part of a large recent burn in the southeastern portion of the study area. Mature conifer stands are relatively rare, and much of the variation in vegetation within the study area is caused by variation in successional stage due to fire history. Fire is most common within the BWBS zone, but fires also occur in the SWB zone, especially on warm aspects. Once a site has been burned, multiple successional paths are possible depending on what seed sources and seedbeds are available at that site (Parminter, 1983). Regenerating stands are generally mapped as structural stage 3 (not 3a or 3b).

Fluvial processes are another form of natural disturbance. Various successional stages are generally present on active floodplains due to depositional and erosional riparian processes.

Disturbance due to beaver activity is common along small streams and the dams maintain fens along bodies of water.

Photo 1. Aerial view of extensive recent burn (background) in southeastern portion of study area.

Fungal rust disease was observed to be affecting some spruce trees in the SWBmk, but the extent of this disturbance was not ascertained. The rust had orange spores and also infected willows and other species.

At this time, human disturbance is restricted in extent within the Dunedin study area. The linear seismic lines that cross the study area are generally in shrubby stages of regeneration. Seismic lines are too small to map at the 1:50,000 scale of mapping for this project.

4.2 Vegetation Summary Tables

Each ecosystem unit described in this section has an accompanying vegetation summary table. The columns of the tables represent map units of the ecosystem unit that differ by structural stage or modifier. Where similar structural stages of an ecosystem unit have similar vegetation, they are described together. Modifiers of map units are described separately only where the atypical situation was observed to significantly influence vegetation. The common names of species are given in the summary tables; corresponding scientific names are listed in Appendix 1.

The vegetation summary tables employ prominence symbols to diagrammatically indicate species' presence and relative abundance. The prominence classes with their accompanying symbols (adapted from those employed in Green and Klinka, 1994) are described in Table 6. The summary tables also show the average percent cover of each vegetation layer; this should be used as an approximate indication of the relative cover of the layers only.

The bottom row of each table shows the plot numbers that correspond to the map units. Plot numbers beginning with "G" are ground inspections, those beginning with "V" are visual plots, and those beginning with other letters are detailed plots. Corresponding provincial database numbers for detailed plots are listed in Appendix 2. The number of plots at the bottom of each column should be used as an indication of the reliability of the vegetation description of that map unit.

Table 6. Prominence Classes Used in Vegetation Tables

Prominence Class	Symbol		Description
	Species Usually Present[1]	Species Often Present[2]	
1	•	•	< 1% cover
2	••	••	1%-7% cover
3	•••	•••	8%-15% cover
4	••••	••••	16%-25% cover
5	•••••	•••••	>25% cover

1 species present in ≥ 90% of plots (at least 3 plots available)
2 species present in ≥ 50% of plots (at least 3 plots available) <u>or</u> fewer than 3 plots available

4.3 Fort Nelson Moist Warm Boreal White and Black Spruce (BWBSmw2)

4.3.1 Forested Ecosystem Units

AM: 01 SwAt - Step moss

General Description: Productive white spruce, trembling aspen, balsam poplar, or paper birch dominated forest. The shrub and herb layers tend to be better developed in mixed and broadleaf stands. Conifer and mixed stands have well developed moss layers.

Distribution: Common in level areas, on valley slopes of the Dunedin River, and on gully slopes. This unit occurred in all slope positions and slope gradients ranged from level to very steep.

Surficial Material: This unit typically occurs on clayey, silty till blankets and plains and often occurred on clayey, silty lacustrine deposits. It also occurs on rubbly colluvium, inactive silty floodplains, rock plains, and gravelly sandy glaciofluvial terraces.

Soil Development: Gray Luvisols (Orthic, Dark, Gleyed, and Gleyed Dark) were the most common soils associated with this unit. Moister sites had Orthic or Humic Luvic Gleysol soils. Orthic Dystric Brunisols were common where this unit occurred on glaciofluvial deposits. Hemimor and various Moder humus forms were associated with this unit.

Moisture Regime: Mesic (balsam poplar stands are probably subhygric).

Nutrient Regime: Poor - rich.

Mapping Notes: Stand composition codes were used to distinguish between conifer (C), broadleaf (B), and mixed (M) stands. A seral association “am” (01$ At - Sw - Step moss, DeLong *et al.,* 1990) has recently been designated for trembling aspen-dominated stands of this unit by the B.C. Ministry of Environment. Mapped broadleaf AM stands include the “am” seral association, as well as balsam poplar and birch-dominated stands for which seral associations have not been described. This unit was mapped on mesic sites with productive white spruce, trembling aspen, paper birch, or balsam poplar forest cover.

Assumed Typical Situation: Gentle slope; deep, medium-textured soils

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: k, w, q, z, y

Structural Stages: Regenerating stands (structural stage 3) are typically broadleaf-dominated. A related report describes the vegetation of regenerating stands of this unit following fire and clearcut logging disturbance in a nearby study area (Teversham and Veach, 1998)

Vegetation Notes: Table 7 describes the vegetation of mapped AM units. Subalpine fir tends to be codominant with white spruce at higher elevations of the BWBSmw2 (700 to 900 m) adjacent to mapped areas of BWBSwk3. Paper birch dominated stands commonly occur on fine-textured slumping slopes. Balsam poplar dominated stands tend to have more lush shrub and herb layers. Separate descriptions of trembling aspen, balsam poplar, and paper birch stands of this unit can be found in a report describing the ecosystem units of nearby study areas (Teversham and Veach, 1998). Tea-leaved, Scouler’s, variable, and grey-leaved willows occur within this unit. Pink and green wintergreens are the most common representatives of the genus.

Photo 2. Young coniferous forest AM5C (with Jason Hindson; plot GW117)

Photo 3. Young trembling aspen forest AM5B (plot GK28)

Photo 4.
Shrubby site AM3 regenerating from fire isturbance (GS124)

Table 7. AM: 01 SwAt - Step moss

		AM7M AM6M	AM5M	AM7C AM6C AM5C	AM6B AM5B	AMy5M AMy6M	AM4M	AM4C	AM4B	AM3
TREE	average % cover	30	39	30	37	32	50	48	60	<1
	white spruce	**••**	•••	•••		•••	•••	•••••		
	black spruce	**••**								
	trembling aspen	••••	**••••**	••	•••••	••••	•••••		•••••	
	balsam poplar	•••	••		•••		••		•••	
	paper birch	••		••	••		••		••	
	subalpine fir			••••						
SHRUB	average % cover	32	33	25	56	32	5	5	5	60
	white spruce	**••**		••	••					
	black spruce	••				••				
	subalpine fir			••••		••		••		
	balsam poplar	•••••		••						
	trembling aspen									**••••**
	prickly rose	**••**	**••**	••	**••**	••	•	•	••	**••**
	highbush-cranberry	••	**••**	••	**••••**		•	•	••	••
	green alder		•••		•••••		•••	••	•••••	
	soopolallie		••				•		••	••
	willow		••		••		•••	••	••••	**••••**
	Ribes spp.			••	••	••	•		••	**••**
	red-osier dogwood					••				
HERB	average % cover	40	26	35	28	48	10	10	10	37
	bunchberry	•••	••	••••	••		••	•••	••	
	lingonberry	•••					••	••	••	
	trailing raspberry	••	••	••	••	••	••		••	••
	clubmoss	••		•						
	palmate-leaved coltsfoot	••	••	•			••	••	••	••
	common mitrewort		**••**	••		••	••	••	••	••
	fireweed		••	•	••		•	•	••	**••**
	tall bluebells		••	•	••		••	••	••	**••**
	wintergreen		••	•	••		••	••	••	
	twinflower		••	•••			•	••		
	grasses		••	•			••	••	••	**••••**
	meadow horsetail		••							•••
	wood horsetail			•		•••				
	common horsetail					••••				
	wild sarsaparilla				••••					
	ferns					•••				
	American vetch									••
MOSS	average % cover	42	39	40	<1	2	20	90	<1	<1
	step moss	•••••	•••••	•••	•	••	•••	•••••		
	knight's plume		••	••			••	•••		
	red-stemmed feathermoss			•				••		
	freckle pelt lichen			••				••		
PLOTS		S51 GK5 GS44	S12 S69 GJ72 GK37 GS68	GW117	K24 GK28 GK29 GK32 GK38 GK52 GS56 GS61 GS123	GS10 GS11		GJ67 GS102		GS124 GW108 GW109

LL: 02 Pl - Lingonberry - Velvet-leaved blueberry

General Description: Open stunted spruce and lodgepole pine forest with sparse shrub and herb layers, continuous moss carpet, and significant ground lichen cover.

Distribution: Rare within study area; occurs mostly on bedrock terraces adjacent to rivers and occasionally on glaciofluvial terraces.

Surficial Material: Shallow till veneers over bedrock terraces and sandy or sandy gravelly glaciofluvial deposits.

Soil Development: This unit was associated with various soil types: Orthic Gray Luvisol, Gleyed Grey Brown Luvisol, and Orstein Humo-Ferric Podzol. Hemimor and Leptomoder humus forms were associated with this unit.

Moisture Regime: Xeric to subxeric moisture regime on soil surface, but drainage may be moderate or imperfect due to low soil permeability.

Nutrient Regime: Very poor to poor.

Mapping Notes: Interpreted from distinctly light tone on air photographs (ground lichens).

Assumed Typical Situation: Gentle slope; deep, coarse-textured soils

Site Modifiers Assumed (from Assumed Typical Situation): c, d, j

Modifiers Employed: w

Photo 5. Stunted young conifer forest LL3bC (plot K44)

Structural Stages: This unit is susceptible to fires due to its dry moisture regime and lodgepole pine canopy. It is therefore unlikely to develop beyond structural stage 4. Regenerating stands (structural stage 3) vary from broadleaf to conifer dominated.

Vegetation Notes: The species composition (Table 8) of this unit is quite variable.

Table 8. LL: 02 Pl - Lingonberry - Velvet-leaved blueberry

		LL4C	LL3bC	LL3
TREE	average % cover	25	3	<1
	white spruce	• • • • •	• •	
	black spruce	• • • • •	• •	
	lodgepole pine	• •		
	trembling aspen		• •	
	balsam poplar	• •	• •	
SHRUB	average % cover	38	30	50
	lodgepole pine	• •	• • • •	• •
	black spruce	• •	• • •	
	white spruce		• •	
	trembling aspen			• •
	balsam poplar			• •
	Labrador tea	• • • •	• • • •	• • • • •
	prickly rose	• • •	•	• • •
	green alder	• •	• •	• • • •
	Alaska paper birch	• •	• •	• •
	leatherleaf	• •		•
	Scouler's willow		• •	• • • •
	bog blueberry		• •	• •
HERB	average % cover	12	18	15
	lingonberry	• • • •	• •	• •
	crowberry	• •	• •	• •
	twinflower	• •	• •	• •
	bastard toad-flax	• •	• •	• •
	cloudberry	• •		
	bunchberry		• • •	
	common horsetail		• •	
	ground-cedar		• •	
	dwarf blueberry		• •	
MOSS	average % cover	85	75	50
	red-stemmed feathermoss	• • • •	• • • • •	• • •
	step moss		• • • •	
	common green sphagnum	• •		
	common red sphagnum		• •	
	grey reindeer lichen	• • •	• • • •	• • •
	Cladina stellaris	• • • • •	• • •	• • •
	Cladina arbuscula ssp. mitis		• • • •	
	black-foot cladonia	•	• •	•
	horn cladonia	•	•	•
	Cladonia amaurocraea	• •		
	Stereocaulon tomentosum	• • •	• •	• •
	freckle pelt lichen	• •	• •	• •
	green paw lichen	• •	• •	• •
	Flavocetraria cucullata	• •		
PLOTS		S43 K44	S100 GS38	

BK: 03 Sb - Lingonberry - Knight's plume

General Description: Trembling aspen or lodgepole pine dominated forest. The shrub layer is usually well developed, but the herb layer is sparse. The moss layer is well developed in conifer stands but sparse in broadleaf stands.

Distribution: Common within the study area. This unit occurs on crest, upper, and mid slope positions of hills, ridges, and gully slopes. It is more common on warm aspects, and it occurs on slope gradients ranging from level to very steep.

Surficial Material: The unit occur mostly on clayey, silty till but may be found on clayey silty lacustrine deposits, silty rubbly colluvium, and on silty gravelly glaciofluvial deposits.

Soil Development: This forest type commonly develops on Orthic Gray Luvisol soils, but it also develops on Gleyed Gray Luvisol, Gleyed Dark Gray Luvisol, and Orthic Dystric Brunisol soils. Humus forms associated with this unit are Hemimor, Mormoder, and Leptomoder.

Moisture Regime: Submesic

Photo 6.
Young mixed forest BK5M (with Jason Hindson; plot GS40)

Nutrient Regime: Poor - medium

Mapping Notes: Mapped on submesic sites where lodgepole pine or lodgepole pine/trembling aspen stands are present.

Assumed Typical Situation: Gentle slope; crest position; deep, medium-textured soils

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m, r

Modifiers Employed: k, w, q, z, s

Structural Stages: This unit is susceptible to fires due to its dry moisture regime and lodgepole pine component. It is therefore unlikely to develop beyond structural stage 5. Regenerating stands (structural stage 3) vary from broadleaf dominated to conifer dominated.

Vegetation Notes: Table 9 describes the vegetation of mapped BK units. Willows associated with this unit are: Scouler's, grey-leaved, woolly, northern bush, Mackenzie's, and mountain. *Ribes* species associated with this unit are: red swamp currant, skunk currant, northern gooseberry, and black gooseberry.

Photo 7.
Shrubby site regenerating from fire disturbance BKw3 (plot GJ12)

Table 9. BK: 03 Sb - Lingonberry - Knight's plume

		BK5C	BK5M	BK5B	BK4C	BK4M	BK3
TREE	average % cover	32	37	40	60	60	<1
	lodgepole pine	• • • • •	• •	• •	• • • •	• • • •	
	white spruce	• • • •	• • •	• •	• •	• • •	
	trembling aspen	• •	**• • • •**	• • • • •		• • • • •	
	paper birch	• •		•	• •		
	subalpine fir	• •			• • • •		
	black spruce		• • •		•	• • •	
SHRUB	average % cover	38	52	50	25	25	32
	paper birch		• •			• •	• •
	trembling aspen					• •	• •
	lodgepole pine						
	green alder	• • • •	**• • • • •**	• • • • •	• •	• • •	
	willow	• • •	• •	• •	• • •	• •	**• • •**
	Labrador tea	• •	• • • •	• • •	• • •		
	prickly rose	• •	• •	• • •	•	• •	• •
	highbush-cranberry	• •	• •	• •		• •	
	Alaska paper birch	• •			• •		
	scrub birch	• •			• •		
	soopolallie	• •					• •
	bog blueberry	• •			• •		
	Ribes spp.	•		•	•		•
HERB	average % cover	35	24	45	45	25	52
	fireweed	• • •		• •	• •	• •	**• •**
	tall bluebells	• • •				• •	**• • •**
	grasses	• • •			•		
	fuzzy-spiked wildrye						**• • • •**
	stiff clubmoss	• •	• • •	• • • • •	• • • •	• • •	
	ground-cedar	• •	• •	•		• •	
	bunchberry	• •	• • •	• • •	• • • •	• • •	
	lingonberry	• •	• •	• • •	• • •	• • •	
	dwarf blueberry	• •					
	twinflower	• •	• •	•	• •	• •	**• •**
	palmate-leaved coltsfoot	• •		•	• •		
	wintergreen	• •					
	wild strawberry	• •				•	• •
	horsetails	•	• •		• •	• •	• •
	one-sided wintergreen	•		• •			
	American vetch	•					• •
	creamy peavine	•					• •
	trailing raspberry				• •	• •	
	yarrow						• •
	northern bedstraw						• •
MOSS	average % cover	50	45	8	90	45	8
	step moss	• • • • •	• • • •	• • •	• • • • •	• • • •	
	knight's plume	• •	• • • •	•	• • • • •	• • • •	
	red-stemmed feathermoss		• • • •		• • • • •	• • • •	
	fire moss						• • •
	freckle pelt lichen	• •			• • •		
	Cladina spp.	• •			• •		
	Cladonia spp.						• •
PLOTS		S28 S109	GK101 GS36 GS40 GS126 GW115	K2 GK14	GK47 GS47		GJ9 GJ12

BL: 04 Sb - Lingonberry – Coltsfoot

General Description: Dense, poor black spruce or black spruce/lodgepole pine forest. The shrub and herb layers are generally sparse, and a continuous moss carpet is typical.

Distribution: This unit is the most widespread within the study area occurring on level sites and on crests, upper slope, and mid slope positions of hills. Slope gradients range from level to steep.

Surficial Material: This forest type develops on clayey silty till, clayey silty (glacio-) lacustrine deposits, gravelly sandy silty fluvial plains, silty gravelly glaciofluvial terraces, and on silty rubbly colluvium within the study area.

Soil Development: Gleyed Gray Luvisol was the most common soil type found at BL sites followed by Orthic Luvic Gleysol and Orthic Dystric Brunisol soils. This unit also develops on Orthic Gleysol, Orthic Humic Regosol, Orthic Gray Luvisol, Podzolic Gray Luvisol, and Gleyed Brunisolic Gray Luvisol soils.

Moisture Regime: Submesic - subhygric

Nutrient Regime: Very poor - medium

Mapping Notes: This unit was mapped only where Sb, SbPl, or PlSb stands were indicated on the forest cover map and where the moisture regime was judged to be subhygric or drier. This forest type appears uniform and dark toned on aerial photographs.

Assumed Typical Situation: Gentle slope; lower slope or toe position; deep, medium-textured soil

Photo 8.
Pole sapling
conifer forest
BL4C
(plot GS112)

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: k, w

Structural Stages: Old forests of this unit are probably rare due to fire disturbance. Regenerating stands (structural stage 3) vary from broadleaf-dominated to conifer-dominated.

Vegetation Notes: The vegetation of the BL unit is described in Table 10. Paper birch stands have been mapped as AM, however they may be a seral association of BL as well. Willows associated with this unit include Bebb's, short-fruited, pussy, variable, bilberry, meadow, tea-leaved, and Farr's.

Photo 9.
Shrubby site regenerating from fire disturbance BL3 (plot GS121)

Table 10. BL: 04 Sb - Lingonberry - Coltsfoot

		BL6C	BL5C	BL4C	BL3C	BL3
TREE	average % cover	25	30	35	<1	<1
	black spruce	••••	••••	•••••		
	white spruce		•••			
	trembling aspen		••			
SHRUB	average % cover	22	26	3	58	50
	black spruce		•••	••••	••••	••
	lodgepole pine				•••	••
	white spruce					••
	paper birch				••	••
	green alder	•••	•••			••
	Labrador tea	••	•••	••	•••	•••••
	prickly rose	••	••	••	••	••
	willow		••		••	•••
	scrub birch					••
HERB	average % cover	28	31	13	22	20
	bunchberry	•••	•••	•••	••	•••
	lingonberry	••	••	••	••	••
	horsetails		••	••	••	••
	palmate-leaved coltsfoot		••		••	••
	grasses				••	••
	fireweed				•	••
MOSS	average % cover	85	75	90	63	48
	step moss	•••••	•••••	•••••	•••••	••••
	red-stemmed feathermoss	•••••	•••	•••••	•••	•••
	knight's plume	•••••	••••	••••	••	•••
	glow moss				••	••
	fire moss					••
	juniper haircap moss					••
	freckle pelt lichen	••	••	••	••	••
	Cladina spp.				••	••
	Cladonia spp.				••	•••
PLOTS		K36 GJ16 GK40 GS114 GW112	W103 S18 GS7 GS34 GS145 GW114	K13 S50 W134 GJ21 GJ26 GK132 GS54 GS112 GS113 GW105	W120 GJ30 GK45 GS152 GW125 GW128	S151 W116 GS121 GS122

SH: 05 Sw - Currant – Horsetail

SH:pa: 05$ Ac - Alder – Horsetail

General Description: Productive white spruce and mixed white spruce/balsam poplar forest occurring on active floodplains. The “pa” seral association is balsam poplar-dominated.

Distribution: This forest type occurs along active floodplains of rivers and large creeks. The white spruce dominated forests grow on elevated floodplain sites that experience seasonal water table fluctuations but rarely flooding. The seral association “pa” balsam poplar dominated forests grow on floodplain sites that experience periodic flooding and prolonged elevated water table.

Surficial Material: This unit occurs on active floodplain deposits ranging from silty to sandy to gravelly sandy. Coarser deposits are associated with the high-energy riparian conditions as the rivers leave the mountains, while the deposits downriver become increasingly fine.

Soil Development: This unit typically develops on (Gleyed) Cumulic Regosol soils. Humus forms associated with this unit are Hemimor, Mormoder, Mullmoder, and Leptomoder.

Moisture Regime: (Mesic) - Subhygric

Nutrient Regime: Medium - rich

Mapping Notes: This unit is mapped where white spruce and mixed white spruce/balsam poplar forests occur on active floodplains. The seral association “pa” is mapped where balsam poplar stands grow on active floodplains.

Photo 10.
Mature conifer forest SHam6C (plot GJ2)

Assumed Typical Situation: Gentle slope to level; moist, receiving sites; deep, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): c, d, j

Modifiers Employed: a, m

Structural Stages: The seral association "pa" is dominated by balsam poplar and probably does not occur as structural stage 7. The regenerating stand (structural stage 3) is conifer-dominated and results from disturbance caused by an upslope terrain failure.

Vegetation Notes: The vegetation of this unit and its seral association is described in Table 11. Willows associated with this unit include variable, northern bush, Alaska, Scouler's, bilberry, Drummond's, and the red-listed Raup's willow. Mackenzie's, pussy, and bilberry willows are associated with the seral association "pa".

Photo 11.
Mature broadleaf forest
SHam5B:pa
(plot K100)

Table 11. SH: 05 Sw - Currant - Horsetail and SH:pa: 05$ Ac - Alder - Horsetail

		SHa7M SHa6M	SHa7C SHa6C	SHa5M	SHa5C	SHa5B: pa	SHa4C	SHa4B: pa	SHa3
TREE	average % cover	38	15	41	32	35	37	60	<1
	white spruce	••••	∘∘	•••••	∘∘∘∘∘	∘∘	∘∘∘∘∘		
	black spruce		∘∘∘∘∘		∘∘∘∘		∘∘∘∘		
	subalpine fir				∘∘		∘∘		
	balsam poplar	••••		••	∘	••••		∘∘∘∘∘	
	trembling aspen			∘∘∘	∘	∘∘∘∘∘		∘∘∘∘∘	
SHRUB	average % cover	36	22	24	32	45	42	20	40
	white spruce				∘∘		∘∘∘∘		∘∘∘∘
	black spruce				∘∘		∘∘∘∘		∘∘
	subalpine fir				∘∘		∘∘		
	balsam poplar				∘	∘		∘	
	mountain alder	•••	∘∘	∘∘		••••	∘∘	∘∘∘	∘∘
	highbush-cranberry	•••		••	∘∘	∘∘∘	∘∘∘∘	∘∘	
	prickly rose	••	••	•••	∘∘	•••	∘∘		
	red swamp currant	••		∘∘	∘∘	∘	∘∘	∘∘	
	willow		∘∘∘		∘∘∘∘	∘∘	∘∘	∘∘∘	∘∘∘∘
	soopolallie		∘∘		∘∘		∘∘∘		
	Labrador tea				∘∘				
	northern gooseberry						∘∘		
	red-osier dogwood						∘∘		
HERB	average % cover	60	26	32	30	25	48	10	50
	horsetail	•••••	•••	∘∘∘	••	•••	•••••	∘∘∘∘	∘∘∘∘
	tall bluebells	••	•	••	∘∘	∘∘	∘∘		∘∘
	bunchberry	∘∘∘		∘∘∘∘	∘∘∘	∘∘	∘∘		
	trailing raspberry	∘∘∘	∘	∘∘	∘∘		∘∘∘		∘
	common mitrewort	∘∘∘	∘∘	∘∘	∘∘	∘∘	∘∘		
	palmate-leaved coltsfoot	∘∘	∘	∘	∘∘	••	∘		
	mountain monkshood	∘	∘∘	∘	∘∘				
	twinflower		••	∘∘	∘∘	∘∘	∘∘∘		
	grasses		••		∘∘	∘∘	∘∘		∘∘∘∘∘
	one-sided wintergreen		∘∘	∘∘	∘		∘		
	wild strawberry		∘	∘∘					
	dwarf rattlesnake orchid		∘		∘		∘		
	wintergreen		∘			∘			
	fireweed			∘∘	∘∘	∘	∘∘	∘∘	∘∘
	fuzzy-spiked wildrye			∘∘					
	lingonberry				∘∘		∘∘		
	tall larkspur				∘∘		∘∘		∘∘
	tall Jacob's-ladder				∘∘		∘		
	stiff clubmoss				∘∘				
	mountain monkshood				∘∘				
	baneberry						∘∘		
MOSS	average % cover	7	63	67	72	9	62	<1	<1
	step moss		•••••	•••••	∘∘∘∘∘	∘∘∘	∘∘∘∘∘		
	knight's plume	∘∘	•••		∘∘∘		∘∘∘∘		
	red-stemmed feathermoss				∘∘∘∘∘		∘∘∘		
	freckle pelt lichen		••		∘∘				
PLOTS		K9 GS39 GW126	W104 GJ2 GJ25 GW111 GW121	S30 S62 GJ8 GK49 GS33 GS67	W136 GS64	K100 GS59 GS125	S110 GS70		GS42

SD: Sb - Devil's club

General Description: Rich, mixed canopy forest.

Distribution: Occurs on level or gently sloping sites with drainage channels.

Surficial Material: This unit develops on clayey silty till.

Soil Development: The single detailed plot for this unit had Gleyed Dark Gray Luvisol soil with Mormoder humus form.

Moisture Regime: Subhygric

Nutrient Regime: Rich

Mapping Notes: Mapped where forest cover is a mixed canopy often including subalpine fir, and where aerial photographs show small drainage channels through forest. Helicopter based visual plots were helpful in identifying the distribution of this unit.

Assumed Typical Situation: Gentle slope; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: none

Vegetation Notes: The vegetation of this unit is described in Table 12.

Table 12. SD: Sb - Devil's club

		SD6M
TREE	average % cover	45
	black spruce	• • • •
	white spruce	•
	subalpine fir	•
	lodgepole pine	• • •
	trembling aspen	• • • •
	balsam poplar	• •
SHRUB	average % cover	16
	devil's club	• •
	highbush-cranberry	• •
	green alder	• •
	prickly rose	• •
HERB	average % cover	40
	bunchberry	• • • • •
	wild sarsaparilla	• •
	wood horsetail	• •
	common mitrewort	• •
	kidney-leaved violet	• •
	trailing raspberry	• •
MOSS	average % cover	38
	step moss	• • •
	knight's plume	• • •
	red-stemmed feathermoss	• • •
PLOTS		K27 GK22

Photo 12.
Young mixed forest SD6M (plot K27)

BB: 06 Sb - Feathermoss – Bluebells

General Description: Dense, stunted black spruce forest.

Distribution: Common within study area especially in the toe position of slopes, along small creeks and drainage channels, and on fluvial plains. This unit was typically transitional between the BL and BS units.

Surficial Material: This unit develops on organic veneers, clayey silty till, clayey silty glaciolacustrine, and siltly fluvial plains. Permafrost was often present in the organic veneers. In general, forests were more stunted when they occurred on organic veneers.

Soil Development: A wide variety of soils supported this forest type: Gleyed Regosol, Orthic Gleysol, Gleyed Gray Luvisol, Orthic Gray Luvisol, Orthic Dystric Brunisol, Fibrisol, Mesisol, and Mesic Organic Cryosol. Humus forms include Hemimor, Fibrimor, Mesimor, Hydromor, Lignomor, and Saprimoder.

Moisture Regime: Subhygric – hygric

Nutrient Regime: Poor - medium

Photo 13.
Pole sapling conifer forest
BB4C (plot GS48)

Mapping Notes: Mapped in toe positions, on fluvial veneers, on floodplains, and in transitional areas between the BL and BS units. Forest cover for this unit is black spruce, and non-productive black spruce stands are assigned the peaty material on surface ("p") modifier. This forest type appears uniform and dark toned on aerial photographs**.**

Assumed Typical Situation: Level to gentle slope; lower slope position; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: p

Structural Stages: Old forests of this unit are probably rare due to fire history. Regenerating stands (structural stage 3) vary from broadleaf dominated to conifer dominated.

Vegetation Notes: The vegetation of this unit is described in Table 13. Willows of this unit include woolly, pussy, grey-leaved, MacCalla's, bilberry, and balsam willows. Wood horsetail is the most common horsetail of this unit, but others include meadow and common horsetails and dwarf scouring-rush.

Photo 14. Stunted conifer forest BBp3bC (plot GK11)

Table 13. BB: 06 Sb - Feathermoss - Bluebells

		BB6C BB5C	BB4C	BB3bC	BBp3bC	BBp3
TREE	average % cover	25	45	<1	<1	<1
	black spruce	•••••	•••••			
SHRUB	average % cover	25	10	35	57	50
	black spruce	••	••	•••••	•••••	••••
	balsam poplar					••
	willow	•••	••	••		•••
	Labrador tea	••	•••	••	••••	••••
	prickly rose	••	••	•	••	••
	Alaska paper birch	••				
	green alder		•••			
	scrub birch			•	••••	
HERB	average % cover	55	36	12	25	20
	bunchberry	•••	•••	•		••
	lingonberry	••	••	••	••	••
	wood horsetail	••••	••••	•••	•••	•••
	other horsetails	•••••	•••			•
	palmate-leaved coltsfoot	••	••	•		••
	twinflower	••	••			
	tall bluebells	••				•
	cloudberry		•••		•••	••
MOSS	average % cover	48	90	96	92	25
	knight's plume	•••••	••••	•••••		••
	step moss	•••••	•••••	•••••	•••••	••
	red-stemmed feathermoss		•••••	•••••	•••••	••
	common green sphagnum		•••		•••••	
	Polytrichum commune		••			
	freckle pelt lichen		••	••		••
	Cladina spp.				••	••
PLOTS		S25 S103 GK15 GS9 GW119	GS19 GS27 GS48 GS57	GK102	GK11 GS46 GS55 GS58 GS66 GS111 GS144	GW118

BS: 08 Sb - Cloudberry – Sphagnum

General Description: Bog treed with stunted black spruce (BS3bC) or open domed bog (BS3aB, BS2d). May occur as treed bog with internal lawns (collapse scars).

Distribution: Common within the study area; occurs on level and gently sloping sites and in depressions.

Surficial Material: This unit usually develops on Fibric Organic blankets and plains, sometimes with permafrost.

Soil Development: This unit is associated with Fibrisol and Organic Cryosol soils. The humus form is usually Fibrimor.

Moisture Regime: Hygric to subhydric

Nutrient Regime: Very poor to poor

Mapping Notes: Difficult to distinguish from the BW unit, which also has non-productive black spruce cover. The BS and BW units often occur together. This unit has a light and uniform tone on aerial photographs. Open domed bogs are lighter in tone than treed bogs and have a "smeared" appearance. Collapse scars (BS2d), indicating localized permafrost melting (National Wetlands Working Group, 1988), often appear as light spots giving the unit a mottled appearance.

Assumed Typical Situation: Organic bog wetland; level sites

Site Modifiers Assumed (from Assumed Typical Situation): j, p

Modifiers Employed: None

Structural Stages: The trees of this unit are usually stunted due to excessive moisture, and this unit does not exceed structural stage 3b. Structural stage 3a has few very low trees and usually occurs in the centre of a domed bog. Structural stage 2d represents dwarf shrub dominated collapse scar bogs and occurs in complex with BS3b.

Vegetation Notes: The vegetation of this unit is described in Table 14. *Sphagnum* species include common red sphagnum, common brown sphagnum, *S. angustifolium*, and *S. magellanicum*. The cover of *Cladina* spp. ranges from 0% to 15%.

Photo 15. Treed bog BS3bC (plot GK53)

Photo 16. Open domed bog BS2d (plot GK21)

Table 14. BS: 08 Sb - Cloudberry - Sphagnum

		BS3bC	BS3aB	BS2d
SHRUB	average % cover	30	32	3
	black spruce	•••	•	••
	Labrador tea	•••	•••	
	leatherleaf		•••	••
	scrub birch	••	••	
HERB	average % cover	19	14	21
	cloudberry	•••	•••	•••
	lingonberry	••	••	
	bog cranberry	••	••	•
	sedge	••		•
	cottongrass		•	••
	bog-rosemary		••	••
	three-leaved false Solomon's-seal		••	
MOSS	average % cover	87	75	95
	Sphagnum spp.	•••••	•••••	•••••
	red-stemmed feathermoss	•••		••••
	glow moss	••		
	Cladina spp.	••		
PLOTS		J1 K10 S14 GJ13 GK20 GK41 GK53 GK103 GK130 GS16 GS17	J23 GJ24	GK21

BW: 09 Sb – Willow

General Description: Treed bog with stunted black spruce. Sometimes occurs as a treed bog with internal lawns (collapse scars).

Distribution: Usually occurs on level, gently sloping, or depressional sites adjacent to fens.

Surficial Material: This unit typically develops on organic veneers over fine fluvial/lacustrine deposits. Permafrost is commonly associated with this unit.

Soil Development: Terric Fibric Mesisol, Fibrisol, Gleysol, Gleysolic Static Cryosol, Organic Cryosol soils are associated with this wetland unit. Humus forms of this unit are Fibrimor, Mesimor, Hydromor, and Hemimor.

Moisture Regime: Hygric - Subhydric

Nutrient Regime: (Poor) to medium

Mapping Notes: Mapping may underrepresent the distribution of this unit. Difficult to distinguish from the BS unit, which also has non-productive black spruce cover. The BS and BW units often occur together. This unit has a medium and uniform tone on aerial photographs. Collapse scars (BW2b), indicating localized permafrost melting (National Wetlands Working Group, 1988), often appear as light spots giving the unit a mottled appearance.

Assumed Typical Situation: Level sites; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: p

Structural Stages: This trees of this unit are usually stunted due to excessive moisture, and this unit does not exceed structural stage 3b. Structural stage 2d represents sedge dominated collapse scar bogs and occurs in complex with BW3b.

Vegetation Notes: The vegetation of this unit is described in Table 15. Willow species of this unit other than bilberry include bog and grey-leaved willows. Sheathed, yellow bog, and soft-leaved sedges were associated with this unit. *Sphagnum* species include common red sphagnum, *S. angustifolium*, and *S. warnstorfii*.

Photo 17.
Treed bog
BW3bC
(plot GK51)

Table 15. BW: 09 Sb - Willow

		BWp3bC	BWp2b
SHRUB	average % cover	33	5
	black spruce	• • •	
	Labrador tea	• • • • •	
	bilberry willow	• •	• •
	other willows	• •	
	prickly rose	• •	
	shrubby cinquefoil	• •	
	scrub birch	• •	• •
HERB	average % cover	28	40
	cloudberry	• • •	
	lingonberry	• •	
	horsetail	• •	
	sedge	• •	• • • • •
	alpine bearberry	• •	
	palmate-leaved coltsfoot	•	
MOSS	average % cover	96	50
	step moss	• • • • •	
	red-stemmed feathermoss	• • • • •	
	Sphagnum spp.	• • • •	• • •
	glow moss	• • •	
	Cladina spp.	• •	
	freckle pelt lichen	• •	
PLOTS		GJ19 GJ28 GK23 GK51 GK54 GS63 GW100 GW113 GW127	some plots for 3bC include patches of 2b

TB: 10 Lt – Buckbean

General Description: Treed fen with scattered stunted tamarack trees; sometimes occurs with collapse scars.

Distribution: Rare within study area; mostly restricted to the northern portion of the study area, east of the Dunedin River; also occurs in the vicinity of Irene Lake. Develops on wet, level sites often in association with SS and BS units.

Surficial Material: The unit develops on organic and fine fluvial/lacustrine deposits.

Moisture Regime: Subhydric

Nutrient Regime: Medium - rich

Mapping Notes: This unit often occurs in the transition between BS and SS units. This unit has a light, uniform tone on aerial photographs, but collapse scar fens may give it a mottled appearance.

Assumed Typical Situation: Organic fen wetland; medium to rich nutrient regime; level sites

Site Modifiers Assumed (from Assumed Typical Situation): j, p

Modifiers Employed: None

Structural Stages: The trees of this unit are usually stunted due to excessive moisture, and this unit is maintained as structural stage 3b. Structural stage 2a represents forb dominated collapse scar fens and occurs in complex with TB3b.

Vegetation Notes: The vegetation of this unit is described in Table 16. Sedges of this unit include water, cordroot, sparse-leaved, and poor.

Photo 18.
Treed fen TB3bC
(plot 9623766)

Table 16. TB: 10 Lt - Buckbean

		TB3bC	TB2a
SHRUB	average % cover	18	<1
	tamarack	••	
	black spruce	••	
	Labrador tea	••	
	scrub birch	••	
	bog willow	••	
	leatherleaf	••	
HERB	average % cover	38	50
	sedge	•••	••••
	three-leaved false Solomon's-seal	••	
	buckbean	•••••	•••••
	swamp horsetail	••	•••
	marsh cinquefoil	••	
MOSS	average % cover	62	50
	common red sphagnum	•••••	•••••
	glow moss	•••••	•••••
PLOTS		K8 GK34 GS20 GS60	K8

4.3.2 Shrub and Herb-Dominated Ecosystem Units

SB: Sandbar willow

General Description: Willow-dominated, fluvial gravel bars.

Distribution: Occurs primarily on the active floodplains of rivers and large creeks.

Surficial Material: This unit occurs on active floodplain deposits ranging from silty to sandy to gravelly sandy. Coarser deposits are associated with high-energy riparian conditions as the rivers leave the mountains while deposits down river become increasingly fine.

Soil Development: Cumulic Regosol soils are typical of sites supporting this unit. Humus is generally absent.

Moisture Regime: Submesic - subhygric

Nutrient Regime: Medium - rich

Mapping Notes: This unit has a uniform, light-toned appearance on aerial photographs. It can be difficult to distinguish this unit from gravel bars with less than 10% cover of vascular plants (GB).

Assumed Typical Situation: Active floodplain; deep, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): a, c, d, j

Modifiers Employed: None

Structural Stages: This unit is maintained as structural stage 3a due to frequent disturbance by riparian flooding.

Vegetation Notes: The vegetation of this unit is described in Table 17. Willow species of this unit include sandbar, Mackenzie's, Drummond's, and Alaska. Horsetails of this unit are scouring-rush and swamp horsetail. Grasses include bluejoint, polargrass, fuzzy-spiked wildrye, and western bluegrass.

Table 17. SB: Sandbar willow

		SB3aB
SHRUB	average % cover	31
	white spruce	•
	balsam poplar	•••
	willow	••••
	mountain alder	••
HERB	average % cover	60
	yellow mountain-avens	•••••
	horsetail	••
	grasses	•
	American vetch	•
	Canada goldenrod	•
	yarrow	•
PLOTS		GJ3 GK50 GS32 VW107 VW130

Photo 19.
Vegetated gravel bar SB3aB (includes oreground and middle ground; plot GJ3)

WA: Willow – Alder

General Description: Shrubby disclimax following burning of moist forest. Regeneration is inhibited by edaphic conditions.

Distribution: Common within study area. It occurs in moist channels, toe positions, and receiving sites. The unit often co-occurs with drier forest types that have regenerated from fire disturbance.

Surficial Material: Often occurs on clayey silty lacustrine, till, or fluvial deposits.

Soil Development: This unit typically develops on Orthic Gleysol soil. Moder humus forms are common.

Moisture Regime: Subhygric - hygric

Nutrient Regime: Medium - rich

Mapping Notes: This unit has a medium-toned, uniform appearance on aerial photographs. It often appears as "holes" within young or mature forest that has regenerated from fire disturbance. In shrubby areas regenerating from fire, the distribution of WA vs. shrub stages of forested units is inferred from slope position.

Assumed Typical Situation: Gentle slope, deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: k, w

Structural Stages: This disclimax unit does not develop beyond structural stage 3b because regenerating trees compete poorly with willow and alder on subhygric sites.

Vegetation Notes: The vegetation of this unit is described in Table 18. Scouler's and pussy willows were found in plots of this unit. Few-flowered and veiny meadowrue were associated with this unit. Horsetails of this unit were wood and meadow.

Table 18. WA: Willow - Alder

		WA3bB
SHRUB	average % cover	50
	mountain alder	•••••
	willow	•••
	prickly rose	••
HERB	average % cover	88
	bluejoint	•••••
	horsetail	•••
	enchanter's-nightshade	••
	fireweed	••
	meadowrue	•
MOSS	average % cover	5
	leafy moss	••
	step moss	•
PLOTS		J15 GS8 GS41

Photo 20.
Shrubby disclimax WA3bB
(plot GS8).

JB: Tall Jacob's ladder – Bluejoint

General Description: Wet meadow dominated by grass, forbs, and willows. Probably maintained by flooding early in the growing season (flowering phenology was late, relative to other sites).

Distribution: This unit was usually of small area and occurred sporadically along small creeks and in areas of excessive moisture accumulation on gentle slopes.

Surficial Material: This unit develops on clayey, silty fluvial deposits.

Soil Development: Fera Gleysol soils were typically present on sites supporting this unit. Rhizomull humus commonly formed from the decomposition of fine bluejoint roots.

Moisture Regime: Hygric

Nutrient Regime: Rich

Mapping Notes: This structural stages of this unit were difficult to distinguish from aerial photographs. These meadows often co-occur with SS fens.

Assumed Typical Situation: Level to gentle slope, deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: None

Structural Stages: This unit is maintained in structural stage 3a or 3b due to edaphic conditions and possible flooding early in the growing season.

Photo 21.
Wet meadow JB3aB (photograph hows herb-dominated portion; plot GK26)

Vegetation Notes: The vegetation of this unit is described in Table 19. Willows present within this unit include Drummond's, tea-leaved, and *Salix athabascensis x pedicellaris*. *Rumex* species include western and curled dock.

Table 19. JB: Tall Jacob's ladder - Bluejoint

		JB3aB JB3bB
SHRUB	average % cover	25
	willow	• • • • •
HERB	average % cover	90
	bluejoint	• • • • •
	tall Jacob's-ladder	• • • •
	fireweed	• •
	tall larkspur	•
	arrow-leaved groundsel	• • •
	cow-parsnip	• • •
	tall bluebells	• • •
	Rumex spp.	• •
	long-stalked starwort	• •
	large-leaved avens	• •
	stinging nettle	•
PLOTS		K43 GK26 GK48 GK133

SS: Scrub birch - Willow - Water sedge

General Description: Willow - sedge fen. This wetland unit is generally maintained by beaver damming of creeks. It varies a great deal in moisture regime and vegetation composition due to variation in the beaver damming regime. At the 1:50,000 scale, the wetland types encompassed within this unit had to be combined.

Distribution: This unit is common along creeks but generally small in area, except for the large areas covered by this unit along Torpid Creek.

Surficial Material: This wetland type develops on silty fluvial/lacustrine deposits of creeks.

Soil Development: Regosol soils are typical on sites supporting this unit.

Moisture Regime: Subhygric to hydric

Nutrient Regime: Medium to rich

Mapping Notes: This unit is very light-toned on aerial photographs. It often co-occurs with beaver ponds.

Assumed Typical Situation: Fen; level sites; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: None

Structural Stages: This wetland unit does not develop beyond structural stage 3a due to excessive moisture conditions.

Vegetation Notes: The vegetation of this unit is described in Table 20. Willows of this unit include Drummond's, bilberry, northern bush, and Athabasca willows.

Table 20. SS: Scrub birch - Willow - Water sedge

		SS3aB	SS2b
SHRUB	average % cover	37	<1
	black spruce	◦◦	
	willow	•••••	◦
HERB	average % cover	38	73
	water sedge	•••••	•••••
	Ross' sedge		◦◦◦◦
	marsh cinquefoil	◦◦	◦◦◦
	bluejoint		◦◦◦
PLOTS		GK55 GS13 GW122	K1 GK7 GS24 GS35 GS53 GS65 GS104

Photo 22. Shrub fen SS3aB (plot K1)

Photo 23. Sedge fen SS2b (plot VK35)

4.3.3 Non-Vegetated, Sparsely Vegetated, and Anthropogenic Units - BWBSmw2

Table 21. Non-Vegetated, Sparsely Vegetated, and Anthropogenic Units of the BWBSmw2

Map Unit	Unit Name	Structural Stage	Modifiers Used	Description	Vegetation (where present)
CL	Cliff	1	k, w	Steep, vertical, or overhanging rock face	Sparse vegetation of tree saplings, willow, prickly rose, forbs, and mosses
ES	Exposed Soil	1	k, w, q, z	Recent slides along valley slopes or anthropogenic clearings associated with an airstrip	Recent slides are unvegetated, but when locally stabilized, they will succeed to birch-dominated mesic forests; anthropogenic clearings have scattered vegetation similar to adjacent ecosystem units
GB	Gravel Bar	1	-	Unconsolidated deposits in the active floodplains of rivers (mostly Dunedin River and Snake Creek) that remain inundated for prolonged periods throughout the year	Scattered vegetation composed of species found in the SB unit
LA	Lake	-	-	Includes Irene Lake and smaller, unnamed lakes	Lake edges are vegetated with sedges, willows, and sweet gale
PD	Pond	-	-	Small body of water greater than 2 m deep; includes creeks with stagnant water due to beaver damming	Pond edges are generally vegetated with sedges; wild calla may grow in beaver ponds
RI	River	-	-	Includes Dunedin River, Snake Creek, and Torpid Creek	Unvegetated
RO	Rock Outcrop	1	w	A gentle to steep bedrock outcropping, with little soil development and sparse vegetative cover	Moss and lichen species predominate
TA	Talus	1		Angular rock fragments accumulated at the foot of steep rock slopes as a result of successive rock falls.	A sparse herb layer of three-toothed saxifrage, fragrant wood fern, fragile fern, alpine bluegrass, spike trisetum, mountain monkshood occurs with a well developed moss layer of stepmoss, plated rocktripe, crustose lichen spp., *Cladina* spp., crumpled-leaf moss, ragged snow lichen, and hoary rock moss

Photo 24.
Exposed soil ES1 (plot VJ70).

Photo 25.
Irene Lake (LA) in middle ground with ponds (PD) and fen (SS2b/3aB) in foreground

Photo 26.
Lower Dunedin River (RI)

4.4 Kledo Wet Cool Boreal White and Black Spruce (BWBSwk3)

4.4.1 Forested Ecosystem Units

LC: Lodgepole pine – crowberry

General Description: Stunted lodgepole pine-dominated forest.

Distribution: Restricted to crest and upper slope positions of the ridges that delineate the study area on the eastern and western sides.

Surficial Material: This unit develops on gravelly silty colluvial veneers over bedrock.

Soil Development: Orthic Dystric Brunisol soils are typical on sites supporting this unit. Hemimor humus form is associated with this unit.

Moisture Regime: Subxeric - submesic

Nutrient Regime: Poor

Mapping Notes: This unit is mapped where on crest and upper slope positions where the forest cover is dominated by lodgepole pine.

Assumed Typical Situation: Gentle slope; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, j

Modifiers Employed: w, k

Photo 27. Young stunted forest LC3bC (plot GS101)

Structural Stages: This unit is unlikely to grow to structural stage 7 because of fire disturbance (enhanced by the exposed ridgetop topography). Some stands of this unit do not develop beyond structural stage 3b because they are regularly subject to fires and/or because they are edaphically stunted. Regenerating stands (structural stage 3) vary from broadleaf dominated to conifer dominated.

Vegetation Notes: The vegetation of this unit is described in Table 22. An atypical plot had 15% cover of Steven's spirea.

Table 22. LC: Lodgepole pine - Crowberry

		LC6C LC5C LC4C	LC3bC	LC3
TREE	average % cover	30	<1	<1
	lodgepole pine	••••		
	subalpine fir	••••		
	black spruce	•••		
SHRUB	average % cover	25	46	50
	lodgepole pine		••••	•
	subalpine fir		••••	
	black spruce		•••	
	Labrador tea	••••	••••	••••
	black huckleberry	•••	•••	•••
	green alder	••	•••	•••••
HERB	average % cover	30	34	30
	Crowberry	•••	•••	•••
	Bunchberry	•••	•••	•••
	Lingonberry	••	••	••
	stiff clubmoss	•••	•••	•••
MOSS	average % cover	75	75	30
	step moss	•••••	•••••	•••
	red-stemmed feathermoss	•••••	•••••	•••
	knight's plume	•••••	•••••	•••
PLOTS			S3 S116 GS101	

FH: Subalpine fir - Black huckleberry

General Description: Subalpine fir forest.

Distribution: Occurs on the mid slope positions of the ridges that delineate the study area on the eastern and western sides.

Surficial Material: This unit develops on gravelly silty colluvial veneers over bedrock.

Soil Development: Orthic Dystric Brunisol soils are typical on sites supporting this unit. Hemimor humus form is associated with this unit.

Moisture Regime: Submesic - mesic

Nutrient Regime: Poor to medium

Mapping Notes: This unit was mapped on mid slope positions where subalpine fir-dominated forest cover occurred.

Assumed Typical Situation: Gentle slope; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, j

Modifiers Employed: k, w

Structural Stages: This unit is unlikely to develop to structural stage 7 because of fire disturbance (enhanced by the exposed ridgetop topography). Regenerating stands (structural stage 3) vary from broadleaf dominated to conifer dominated.

Vegetation Notes: The vegetation of this unit is described in Table 23. Willows of this unit include balsam willow.

Table 23. FH: Subalpine fir - Black huckleberry

		FH6C FH5C	FH4C	FH3
TREE	average % cover	22	35	<1
	subalpine fir	• • • •	• • • • •	
	black spruce	• •		
	paper birch	• •		
SHRUB	average % cover	27	10	50
	subalpine fir	• • •		
	lodgepole pine	• •	• •	•
	paper birch	• •		• • •
	green alder	• • •		• • • •
	black huckleberry	• •	• • •	• •
	Willow	• •		• • • •
	western mountain-ash	•		
	red swamp currant	•		
HERB	average % cover	30	12	
	stiff clubmoss	• • •	•	•
	Bunchberry	• • •	• • •	• • •
	Nagoonberry	• • •	•	•
	palmate-leaved coltsfoot	•		
MOSS	average % cover	50	97	30
	red-stemmed feathermoss	• • • •	• • •	• •
	knight's plume	• • • •	• •	• •
	step moss	• •	• • • • •	• • • •
PLOTS		K4 GK19	K46	

Photo 28.
Pole sapling conifer forest
FH4C (plot K46).

LB: Lodgepole pine – Bluejoint

General Description: Moist forest dominated by lodgepole pine or white spruce.

Distribution: This unit occurred on lower slope positions and on receiving sites on the ridges that delineate the study area on the eastern and western sides.

Surficial Material: This unit develops on gravelly silty colluvium.

Moisture Regime: Subhygric

Nutrient Regime: Medium

Mapping Notes: This unit was mapped in toe positions, and on receiving sites. Forest cover was variable.

Assumed Typical Situation: Gentle slope; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, j

Modifiers Employed: w

Structural Stages: This unit is unlikely to develop to structural stage 7 because of fire disturbance (enhanced by the exposed ridgetop topography).

Vegetation Notes: The vegetation of this unit is described in Table 24. Willows of this unit include Alaska and grey-leaved willows.

Table 24. LB: Lodgepole pine - Bluejoint

		LB6C **LB5C**
TREE	average % cover	25
	white spruce	• • • •
	lodgepole pine	• •
SHRUB	average % cover	45
	green alder	• • • •
	mountain alder	• •
	red raspberry	• •
	red swamp currant	• •
	Willow	• •
HERB	average % cover	55
	stiff clubmoss	• • • •
	Bluejoint	• • •
	Fireweed	• •
	Bunchberry	• •
	clasping twistedstalk	• •
MOSS	average % cover	4
	step moss	• •
	Brachythecium salebrosum	• •
PLOTS		GS4 GS118

Photo 29.
Young conifer forest LBw5C
(plot GS4)

4.4.2 Shrub and Herb-Dominated Ecosystem Units

WA: Willow – Alder

General Description: Shrubby disclimax following burning of moist forest. Regeneration is inhibited by edaphic conditions. Similar to WA unit of the BWBSmw2.

Distribution: This unit occurs in moist channels, toe positions, and receiving sites. The unit often co-occurs with drier forest types that have regenerated from fire disturbance.

Surficial Material: Often occurs on clayey silty lacustrine, till, or fluvial deposits.

Soil Development: This unit typically develops on Orthic Gleysol soil. Moder humus forms are common.

Moisture Regime: Subhygric - hygric

Nutrient Regime: Medium to rich

Mapping Notes: This unit has a medium toned, uniform appearance on aerial photographs. It often appears as “holes” within young or mature forest that has regenerated from fire disturbance. In shrubby areas regenerating from fire, the distribution of WA vs. shrub stages of forested units is inferred from slope position.

Assumed Typical Situation: Gentle slope; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, j

Modifiers Employed: k, w

Structural Stages: This disclimax unit does not develop beyond structural stage 3b because regenerating trees compete poorly with willow and alder on subhygric sites.

Vegetation Notes: The vegetation of this unit is described in Table 25.

Table 25. WA: Willow - Alder

		WA3bB
SHRUB	average % cover	50
	black spruce	•
	subalpine fir	•
	Willow	• • • • •
	green alder	• • •
HERB	average % cover	42
	Bluejoint	• • • • •
	yellow anemone	• •
	arrow-leaved groundsel	• •
	common horsetail	• •
	cow-parsnip	• •
	three-leaved false Solomon's-seal	•
MOSS	average % cover	
	common green sphagnum	• •
PLOTS		GS6

BA: Bog blueberry - Alpine bearberry

General Description: Vegetated rock outcrop.

Distribution: Occurs on crest positions of the ridges that delineate the study area on the eastern and western sides.

Surficial Material: This unit develops on thin veneers of weathered bedrock.

Soil Development: The sites supporting this unit have Regosol soils and little humus development.

Moisture Regime: Subxeric

Nutrient Regime: Poor

Mapping Notes: This unit appears uniform and light in tone on aerial photographs.

Assumed Typical Situation: Crest or upper slope position; shallow, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): c, r, s

Modifiers Employed: None

Structural Stages: This unit is maintained in the low shrub stage by climatic exposure in combination with shallow, rapidly drained soil.

Vegetation Notes: The vegetation of this unit is described in Table 26. Grey and spreading arctic sedges were associated with this unit. Woodrushes of the unit include small-flowered and confused woodrushes.

Photo 30. Vegetated rock outcrop BA3aB (with Derrick Marven; plot GS1)

Table 26. BA: Bog blueberry - Alpine bearberry

		BA3aB
SHRUB	average % cover	23
	bog blueberry	• • • •
	green alder	• •
HERB	average % cover	39
	alpine bearberry	• • • • •
	Lingonberry	• • •
	Crowberry	• •
	Bunchberry	• •
	three-toothed saxifrage	• •
	Fireweed	•
	one-flowered cinquefoil	•
	Woodrush	•
	Sedge	•
MOSS	average % cover	15
	Stereocaulon tomentosum	• • •
	Flavocetraria cucullata	• •
PLOTS		GK17 GS1

JB: Tall Jacob's ladder – Bluejoint

General Description: Wet meadow dominated by grass, forbs, and willows. Probably maintained by flooding early in the growing season (flowering phenology was late relative to other sites). Similar to JB unit of the BWBSmw2.

Distribution: This unit was usually of small area and occurred sporadically along small creeks and in areas of excessive moisture accumulation on gentle slopes.

Surficial Material: This unit develops on clayey silty fluvial deposits.

Soil Development: Fera Gleysol soils were typically present on sites supporting this unit. Rhizomull humus commonly formed from the decomposition of fine bluejoint roots.

Moisture Regime: Hygric

Nutrient Regime: Rich

Mapping Notes: This structural stages of this unit were difficult to distinguish from aerial photographs.

Assumed Typical Situation: Gentle slope; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, j

Structural Stages: This unit does not develop beyond structural stage 3b due to edaphic conditions and possible flooding early in the growing season.

Vegetation Notes: The vegetation of this unit is described in Table 27.

Table 27. JB: Tall Jacob's ladder – Bluejoint

		JB3aB
SHRUB	average % cover	20
	Willow	• • • •
HERB	average % cover	90
	Bluejoint	• • • • •
	marsh cinquefoil	• • •
	water sedge	• •
	arrow-leaved groundsel	• •
	common horsetail	• •
	tall Jacob's-ladder	• •
	three-leaved false Solomon's-seal	•
MOSS	average % cover	2
	common leafy moss	• •
PLOTS		GS5

FL: Fragrant wood fern – Lichen

General Description: Vegetated talus

Distribution: This rare unit occurred at the base of cliffs.

Surficial Material: This unit develops on talus.

Moisture Regime: Xeric

Nutrient Regime: Very poor

Mapping Notes: This unit was light in tone on aerial photographs.

Assumed Typical Situation: Colluvial lower slope; deep, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): c, d

Modifiers Employed: k

Vegetation Notes: The vegetation of this unit is described in Table 28.

Table 28. FL: Fragrant wood fern - Lichen

		FL2d
SHRUB	average % cover	8
	black spruce	• •
	bog blueberry	• •
	grey-leaved willow	• •
	scrub birch	• •
HERB	average % cover	16
	alpine bearberry	• • •
	fragrant wood fern	• •
	three-toothed saxifrage	• •
	Fireweed	•
MOSS	average % cover	40
	Flavocetraria cucullata	• • •
	plated rocktripe	• • •
	Cladina spp.	• • •
	Stereocaulon tomentosum	• •
PLOTS		GS117

4.4.3 Non-Vegetated and Sparsely Vegetated Units

Table 29. Non-Vegetated and Sparsely Vegetated Units of the BWBSwk3

Map Unit	Unit Name	Structural Stage	Modifiers Used	Description	Vegetation (where present)
CL	Cliff	1	k, w	A steep, vertical, or overhanging rock face	Sparse vegetation of tree saplings, willow, pricky rose, forbs, and mosses
RU	Rubble	1		Small angular rock fragments found at the bottom of cliffs or steep rock outcrops	Usually unvegetated due to slope instability; where rubble is stablized a sparse herb layer of three-toothed saxifrage, fragrant wood fern, fragile fern, alpine bluegrass, spike trisetum, mountain monkshood occurs with a well developed moss layer of stepmoss, plated rocktripe, crustose lichen spp., *Cladina* spp., crumpled-leaf moss, ragged snow lichen, and hoary rock moss

4.5 Moist Cool Spruce Willow Birch (SWBmk)

4.5.1 Woodland Ecosystem Units

SB

General Description: Subalpine white spruce woodland with variable canopy closure.

Distribution: This unit occurs on level to sloping sites.

Surficial Material: This woodland type develops on silty gravelly fluvial fans, gravelly fluvioglacial terraces, gravelly silty colluvial veneers, and on clayey silty till.

Soil Development: This unit develops on Orthic Gray Luvisol and Orthic Eutric Brunisol soils. The Hemimor humus form is typical for this unit.

Moisture Regime: Mesic

Photo 31. Mature subalpine conifer woodland SB6C (with Carolyn Whittaker; plot GK149 showing an open canopy form of this woodland type).

Nutrient Regime: Poor to medium

Mapping Notes: Generally mapped on level sites where tree growth is good.

Assumed Typical Situation: Gentle slopes; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: w, k

Structural Stages: This unit may also occur as stunted, mature woodland (structural stage 3b). Structural stage 7 is probably rare due to frequent fire and disease disturbance in the SWB.

Vegetation Notes: The vegetation of this unit is described in Table 30.

Table 30. SB

		SB6C
TREE	average % cover	21
	white spruce	••
	lodgepole pine	••••
	black spruce	••
SHRUB	average % cover	37
	white spruce	••
	lodgepole pine	••
	mountain alder	••
	grey-leaved willow	•••
	scrub birch	•••
	Labrador tea	•••
	prickly rose	••
HERB	average % cover	33
	Bunchberry	•••
	Lingonberry	•••
	Crowberry	••••
	Twinflower	••
	Fireweed	••
	tall bluebells	••
	Horsetails	••
	one-sided wintergreen	••
MOSS	average % cover	87
	step moss	•••••
	red-stemmed feathermoss	••••
	knight’s plume	••••
	glow moss	••
	freckle pelt lichen	••
PLOTS		GK 137 GK149 GW131 GW132

SK

General Description: Subalpine white spruce or lodgepole pine woodlands.

Distribution: Mostly restricted to warm slopes. Common on crest and upper slope positions and on coarse deposits in mid and lower slope positions. Where this unit occurs on coarse active floodplain, it is mapped with an active floodplain modifier ("a").

Surficial Material: This woodland type develops on gravelly silty till, rubbly colluvium, and on sandy gravelly glaciofluvial terraces and slopes. It also occurs on coarse active fluvial high benches.

Soil Development: This unit develops on sites with the following soil types: Orthic Eutric Brunisol, Orthic Gray Luvisol, Orthic Humo-Ferric Podzol, and Orthic Melanic Brunisol. The humus form is typically Hemimor, but Mormoder and Leptomoder forms are also found.

Moisture Regime: Xeric - subxeric

Nutrient Regime: Medium

Mapping Notes: This unit was mapped on warm slopes and where either slope position or coarse surficial material was judged to maintain xeric to subxeric soil moisture conditions. Forested floodplains of the SWBmk were mapped as SKa.

Assumed Typical Situation: Significant slopes; warm aspects; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, w

Modifiers Employed: a, j, w, k

Photo 32.
Stunted young subalpine conifer woodland
SKw3bC
(plot 9623998)

Structural Stages: Structural stage 3 stands vary in their stand composition This unit may also occur as mature woodland (structural stage 6). Structural stage 7 is probably rare due to frequent fire and disease disturbance in the SWB.

Vegetation Notes: The vegetation of this unit is described in Table 31. Willows of this unit are bilberry, Scouler's, grey-leaved, Bebb's, northern bush, Alaska, and variable.

Photo 33.
Stunted young subalpine conifer woodland along One Thirteen Creek SKaj3bC (humus disturbed by grizzly bears digging for alpine hedysarum; plot GK173).

Table 31. SK

		SK5C	SK3bC	SKaj3bC SKaj5C	SK3
TREE	average % cover	15	1	3	1
	white spruce	••	•	••	•
	lodgepole pine	•••			
SHRUB	average % cover	17	48	15	40
	white spruce	••	••••	••	•••
	lodgepole pine	•			
	trembling aspen	••			•••
	balsam poplar	•		••	•••••
	willow	••	••	••	••
	soopolallie	••		••	
	common juniper	••		•	•••
	shrubby cinquefoil	•	••		•
	scrub birch		••		
	Labrador tea			••	
	green alder				••
HERB	average % cover	28	30	20	62
	fireweed	•	•		••
	lingonberry	•••	••	••	••
	fuzzy-spiked wildrye	•••	•••	•••	•••••
	alpine hedysarum	•	••	••	••
	tall bluebells	•			••
	kinnikinnick		••	•	••
	twinflower			••	••
	bunchberry				•••
	tall larkspur				••
	wild strawberry				••
MOSS	average % cover	32	71	80	
	step moss	••••	•••••	•••••	•••
	freckle pelt lichen		••	•	••
PLOTS		J57 GK170 GK172	GJ38 GJ43 GK116 GS142 GS154	GK173 GJ63	S141 GJ44

SW

General Description: Subalpine white spruce or trembling aspen woodland.

Distribution: Common on warm and east-facing slopes; usually on mid and lower slope positions. Slope gradients range from gentle to steep.

Surficial Material: This unit develops on rubbly silty colluvium, rubbly clayey silty till, and gravelly fluvioglacial slopes.

Soil Development: Soil types associated with this unit include: Orthic Eutric Brunisol, Gleyed Eutric Brunisol, Gleyed Gray Luvisol, and Orthic Gleysol. Hemimor and Mormoder humus forms occur with this unit.

Moisture Regime: Submesic to mesic

Nutrient Regime: Medium

Mapping Notes: This unit was commonly mapped on warm and east aspects in mid and lower slope positions.

Photo 34.
Mature subalpine conifer woodland SW6C (plot GK156).

Assumed Typical Situation: Gentle slopes; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: k, w

Structural Stages: Structural stage 3b is mature woodland but stunted due to climatic conditions. Structural stage 7 is probably rare due to frequent fire and disease disturbance in the SWB.

Vegetation Notes: The vegetation of this unit is described in Table 32. Willows of this unit include grey-leaved, bilberry, northern bush, and Alaska willows.

Photo 35.
Young broadleaf woodland SWw5B (with Julie Williams; plot S109)

Table 32. SW

		SW6C	SW5B	SW3bC
TREE	average % cover	17	50	1
	white spruce	••••	••	••
	trembling aspen		•••••	
	balsam poplar		•••	
SHRUB	average % cover	20	10	6
	white spruce	••	••	••
	balsam poplar		••	
	willow	•••	••	••
	prickly rose	••	••	
	scrub birch	••		
	soopollalie		••	•
HERB	average % cover	38	85	<1
	fuzzy-spiked wildrye	•••	•••••	
	fireweed	••	••	
	tall bluebells	••	••	
	mountain monkshood	••	••••	
	horsetails	••	•	
	twinflower	••		
	bunchberry	••		
	lingonberry	••		
	arctic lupine	•		•
	one-sided wintergreen	•		•
	alpine hedysarum		••	•
	northern bedstraw		••	
	wild strawberry		••	
	creamy peavine		••	
	tall larkspur		••	
MOSS	average % cover	65	<1	98
	step moss	•••••		•••••
	knight's plume	•••		
	red-stemmed feathermoss	••		
	freckle pelt lichen	••	•	
PLOTS		J49 GGB07 GK47 GK138 GK156 GK159 GK160	W135	GK171

SL

General Description: Open subalpine white spruce woodland.

Distribution: Generally occurs in mid to lower slope positions, generally on cool aspects.

Surficial Material: Usually occurs on silty rubbly colluvium.

Soil Development: This unit occurs on Orthic Humic Regosol, Orthic Eutric Brunisol, and Orthic Gray Luvisol soils. Hemimor humus form is typical.

Moisture Regime: Mesic - subhygric

Nutrient Regime: Medium

Mapping Notes: Generally mapped in cool lower slope positions where tree growth is relatively good.

Assumed Typical Situation: Significant slopes; cool aspects; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, w, m

Photo 36.
Mature subalpine conifer woodland SL6C (plot GK155)

Modifiers Employed: j, k, w

Structural Stages: Structural stage 3b is mature woodland, but stunted due to climatic conditions. Structural stage 7 is probably rare due to frequent fire and disease disturbance in the SWB.

Vegetation Notes: The vegetation of this unit is described in Table 33. Bebb's, grey-leaved, pussy, woolly, and mountain willows occur within this unit.

Table 33. SL

		SL6C	SL3bC
TREE	average % cover	12	1
	white spruce	•••	•
SHRUB	average % cover	19	58
	white spruce	••	•••
	subalpine fir	••	••
	other willows	••	••••
	grey-leaved willow	••	••
	scrub birch	••	•••••
	Labrador tea	••	•
	prickly rose	••	
HERB	average % cover	49	48
	tall bluebells	•••	••
	twinflower	••	••
	horsetails	••	
	tall Jacob's-ladder	•	••
	bluejoint	••••	••
	fuzzy-spiked wildrye	••	
	Altai fescue		••
	bunchberry	•••	
	lingonberry	••	••
	mountain monkshood	••	••
	fireweed	••	
	wild strawberry	••	
	Aleutian mugwort	••	
	tall larkspur	••	
	yarrow	•	••
MOSS	average % cover	51	70
	step moss	•••••	•••••
	knight's plume	••	
	red-stemmed feathermoss		••••
	glow moss		•••
	freckle pelt lichen	••	••
PLOTS		GK124 GK125 GK155 GW138	GK122 GS139

SC

General Description: Open stunted subalpine woodland.

Distribution: Common on north-facing significant slopes. Occurs on upper to lower slope positions.

Surficial Material: This unit typically develops on rubbly colluvial slopes.

Soil Development: Soil types associated with this unit include Humic Regosol, Gleyed Gray Luvisol, and Orthic Gleysol. Hemimor humus form is typical.

Moisture Regime: Mesic to subhygric

Nutrient Regime: Poor

Mapping Notes: Mapped on north aspects where tree growth is poor. This unit appears lighter in tone than other wooded units on aerial photographs. The “drier than average” modifier (x) is used where this unit has developed extensive ground lichen cover.

Assumed Typical Situation: significant slopes; cool aspects; deep, medium-textured soil

Photo 37.
Stunted subalpine woodland SC3bC
(plot GK127)

Site Modifiers Assumed (from Assumed Typical Situation): d, k, m

Modifiers Employed: j, w, x

Structural Stages: This unit is not expected to develop beyond structural stage 3b (stunted woodland with sparse tree cover) due to the climatic conditions on the cold slopes where this unit occurs.

Vegetation Notes: The vegetation of this unit is described in Table 34. Willows of this unit include grey-leaved, northern bush, bilberry, and woolly willows. *Cladina* species include grey reindeer lichen, *C. arbuscula* ssp. *mitis*, and *C. stellaris*. *Cladonia* species include black-foot cladonia, horn cladonia, and *C. cenotea*.

Photo 38.
Vegetated rubble SCx3aB
(plot GK177)

Table 34. SC

		SC3bC	SC3aB	SCkx3bC	SCkx3aB
SHRUB	average % cover	25	51	50	7
	white spruce	•••	••	••••	••
	subalpine fir	•••			
	black spruce			••	
	scrub birch	•••	•••••	•••••	•
	willow	••	•••	••	•
	Labrador tea	••	••	•••	••
	bog blueberry	••	••	••	••
HERB	average % cover	30	14	30	8
	lingonberry	••	••	•••	•
	crowberry	•••••	••	••	••
	netted willow	•	•	••	
	alpine bearberry	•	•		••
	tall bluebells	•	•		
	dwarf scouring-rush	•	••	••	
	Altai fescue		••		
	polargrass		••		
	entire-leaved mountain-avens			••	••
	bastard toad-flax			••	
	sedge				••
MOSS	average % cover	91	95	95	70
	step moss	•••••	•••••	•••••	••
	red-stemmed feathermoss	•••••	•••••	•••••	
	Aulacomnium turgidum	•••	•••	••	•
	knight's plume	•••	••		
	glow moss		••		
	sickle moss				••
	Cladina spp.	••	•	•••••	•••••
	freckle pelt lichen	••	••	••	
	Flavocetraria cucullata		••	••	••
PLOTS		GK127 GK151 GK174 GW139	J46 S140	GS153	GK177

SH

General Description: Subalpine woodland.

Distribution: Occurs in lower slope, toe, and depressional slope positions.

Surficial Material: This unit develops on colluvial and fluvial deposits.

Moisture Regime: Subhygric to hygric.

Nutrient Regime: Medium to rich

Mapping Notes: Mapped in lower slope, toe, and depressional slope positions where tree growth is good and where drainage channels are visible on aerial photographs.

Assumed Typical Situation: Gentle slopes; deep, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): c, d, j

Modifiers Employed: w, k

Structural Stages: Structural stage 7 is probably rare due to frequent fire and disease disturbance in the SWB.

Vegetation Notes: The vegetation of this unit is described in Table 35.

Photo 39. Subalpine mature woodland SH6C (plot GK112)

Table 35. SH

		SH6C
TREE	average % cover	20
	white spruce	• • • •
SHRUB	average % cover	25
	white spruce	• •
	grey-leaved willow	• • • •
	bilberry willow	• •
	scrub birch	• •
HERB	average % cover	25
	tall bluebells	• •
	meadow horsetail	• •
	bluejoint	• •
	alpine bearberry	• •
	palmate-leaved coltsfoot	• •
	Altai fescue	• •
	arctic lupine	• •
	lingonberry	• •
	four-parted gentian	• •
MOSS	average % cover	95
	step moss	• • • • •
	red-stemmed feathermoss	• • • •
	glow moss	• • •
	knight's plume	• •
	freckle pelt lichen	• •
PLOTS		GK112

4.5.2 Shrub and Herb-Dominated Ecosystem Units

SP: Sw – Polargrass

General Description: Permafrost bog with sparse, stunted tree cover.

Distribution: This unit develops in level and sloping drainage channels and on north-facing steep slopes.

Surficial Material: This unit occurs on fibric organic deposits ranging in thickness from thin veneers to blankets over mineral deposits including clayey silty till.

Soil Development: Static Cryosol and Organic Cryosol soils support this unit.

Moisture Regime: Hygric - subhydric

Nutrient Regime: Very poor to poor

Mapping Notes: This unit is common within the SWBmk; it is mapped in drainage channels and on north aspect slopes. It is light in tone on aerial photographs and conforms to the underlying topography. Where north aspect slopes are in shade on aerial photographs, it is difficult to distinguish the SC unit from SP; in such cases, SC was usually mapped.

Assumed Typical Situation: Permafrost bog; gentle slopes

Site Modifiers Assumed (from Assumed Typical Situation): j

Modifiers Employed: k

Structural Stages: This unit is not expected to advance beyond structural stage 3a. It develops on permafrost, and tree growth is adversely affected by climatic conditions, edaphic conditions, and shallow rooting depth.

Vegetation Notes: This unit is described in Table 37; willows of this unit include grey-leaved, northern bush, and bilberry willows.

Table 36. SP: Sw - Polargrass

		SPk3aB
SHRUB	average % cover	25
	white spruce	• •
	Labrador tea	• •
	green alder	• •
	willow	• • •
	scrub birch	• •
HERB	average % cover	15
	lingonberry	• •
	crowberry	• •
	polargrass	• •
	cloudberry	• •
	dwarf scouring-rush	• •
	alpine bearberry	• •
	bog-rosemary	• •
	tall bluebells	• •
MOSS	average % cover	90
	step moss	• • • • •
	common red sphagnum	• • • •
	Sphagnum warnstorfii	• •
	red-stemmed feathermoss	• • •
	knight's plume	• • •
	glow moss	• • •
PLOTS		GK139

Photo 40.
Permafrost bog SPk3aB (plot GK139)

JB: Tall Jacob's ladder – Bluejoint

General Description: Wet meadow dominated by grass, forbs, and willows. Probably maintained by flooding early in the growing season (flowering phenology was late relative to other sites).

Distribution: This unit was usually of small area and occurred sporadically along small creeks and in areas of excessive moisture accumulation on gentle slopes.

Surficial Material: This unit usually develops on clayey silty fluvial deposits.

Soil Development: Gleysol soils were typically present on sites supporting this unit.

Moisture Regime: Hygric

Nutrient Regime: Rich

Mapping Notes: This structural stages of this unit were difficult to distinguish from aerial photographs.

Assumed Typical Situation: Level to gentle slopes; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, m, j

Modifiers Employed: None

Structural Stages: This unit does not develop beyond structural stage 3b due to edaphic conditions and possible flooding early in the growing season.

Vegetation Notes: The vegetation of this unit is described in Table 37.

Photo 41.
Wet shrubby meadow JB3aB plot GJ51; foreground)

Photo 42. Wet meadow JB2b (with Linda Veach; plot VK158)

Table 37. JB: Tall Jacob's ladder - Bluejoint

		JB3aB	JB2b
SHRUB	average % cover	57	<1
	grey-leaved willow	• • • • •	•
	scrub birch	• • • • •	
	shrubby cinquefoil		•
HERB	average % cover	45	90
	Bluejoint	• • • • •	• • • • •
	fuzzy-spiked wildrye	• • •	• • •
	Altai fescue	• •	• •
	alpine timothy	•	
	Bluegrass	•	
	small-flowered woodrush	• •	
	tall Jacob's-ladder	• • •	• • • •
	Fireweed	• •	• •
	tall larkspur	• •	• •
	cow-parsnip	• •	•
	tall bluebells	• •	•
	Yarrow	• •	• •
	Rumex spp.	•	•
	palmate-leaved coltsfoot	•	•
	mountain monkshood	•	• •
	large-leaved avens	•	• •
MOSS	average % cover	5	<1
	step moss		
	Brachythecium asperrimum		
PLOTS		GJ37 GJ51	VK158

WS: Willow – Sedge

General Description: Willow dominated fen.

Distribution: This unit generally develops in narrow valleys between slopes.

Surficial Material: This unit typically develops on silty fluvial deposits.

Moisture Regime: Subhydric

Nutrient Regime: Poor

Mapping Notes: This unit is difficult to distinguish from wet meadows (JB) on aerial photographs; inferred moisture regime is used to distinguish between them.

Assumed Typical Situation: Fen; level to gentle slopes; deep, medium-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): d, j, m

Modifiers Employed: None

Structural Stages: This wetland unit does not develop beyond structural stage 3a due to excessive moisture conditions.

Vegetation Notes: The vegetation of this unit is described in Table 38. Willows include Barratt's and bog willows.

Photo 43.
Shrubby bog
WS3aB
(plot GK157)

Table 38. WS: Willow - Sedge

		WS3aB
SHRUB	average % cover	40
	white spruce	• •
	willows	• • • • •
	scrub birch	• • •
HERB	average % cover	50
	water sedge	• • • •
	bluejoint	• • • •
	Altai fescue	• •
	Kentucky bluegrass	• •
	small-flowered woodrush	• •
	tall Jacob's-ladder	• •
	fireweed	• •
	tall larkspur	• •
	nagoonberry	• •
MOSS	average % cover	40
	Sphagnum warnstorfii	• • • •
	glow moss	• • •
	step moss	• •
	golden fuzzy fen moss	• •
PLOTS		GK157

WY: Willow - Yellow mountain-avens

General Description: Willow dominated fluvial gravel bars.

Distribution: Occurs on the active floodplains of rivers and creeks.

Surficial Material: This unit occurs on gravelly active floodplain deposits.

Soil Development: Cumulic Regosol soils are typical of sites supporting this unit. Humus is generally absent.

Moisture Regime: Submesic

Nutrient Regime: Medium to rich

Mapping Notes: This unit has a uniform, light-toned appearance on aerial photographs. It can be difficult to distinguish this unit from gravel bars (GB) with less than 10% cover of vascular plants.

Assumed Typical Situation: Active floodplain; deep, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): a, c, d

Modifiers Employed: None

Structural Stages: This unit does not develop beyond structural stage 3a due to frequent disturbance by riparian flooding.

Vegetation Notes: The vegetation of this unit is described in Table 39.

Table 39. WY: Willow - Yellow mountain-avens

		WY3aB
SHRUB	average % cover	10
	balsam poplar	• •
	willow	• • •
HERB	average % cover	30
	yellow mountain-avens	• • • • •
	kinnikinnick	• •
	Astragalus sp.	•
	alpine hedysarum	•
PLOTS		VK150

4.5.3 Non-Vegetated and Sparsely Vegetated Units

Table 40. Non-Vegetated and Sparsely Vegetated Units of the SWBmk

Map Unit	Unit Name	Structural Stage	Modifiers Used	Description	Vegetation (where present)
CL	Cliff	1	k, w	A steep, vertical, or overhanging rock face	Sparse vegetation of tree saplings, willow, prickly rose, forbs, and mosses
GB	Gravel Bar	1	-	Unconsolidated deposits in the active floodplains of rivers (mostly Dunedin River and Snake Creek) that remain inundated for prolonged periods throughout the year	Scattered vegetation composed of species found in the WY unit
PD	Pond	-	-	Small body of water greater than 2 m deep; includes creeks with stagnant water due to beaver damming	Pond edges are generally vegetated with sedges; wild calla may grow in beaver ponds
RI	River	-	-	Includes the Dunedin River and Snake Creek	Unvegetated
RG	Rock Glacier	1a	-	Lobate, ridged accumulation of angular fragments containing interstitial ice; morphologically similar to glaciers	Unvegetated
RU	Rubble	1	k, w	Small angular rock fragments found at the bottom of cliffs or steep rock outcrops; derived from limestone and sandstone bedrock	Usually unvegetated due to slope instability; where rubble is stabilized a sparse herb layer of three-toothed saxifrage, fragrant wood fern, fragile fern, alpine bluegrass, spike trisetum, mountain monkshood occurs with a well developed moss layer of stepmoss, plated rocktripe, crustose lichen spp., *Cladina* spp., crumpled-leaf moss, ragged snow lichen, and hoary rock moss

4.6 Moist Cool Scrub Spruce Willow Birch (SWBmks)

4.6.1 Shrub and Herb-Dominated Ecosystem Units

SA: Scrub birch - Altai fescue

General Description: Subalpine willow birch scrub.

Distribution: Occurs on sloping, level, and receiving sites; commonly on cool aspects.

Surficial Material: This unit occurs on colluvial, till, and glaciofluvial deposits.

Soil Development: This unit develops on Orthic Melanic Brunisol, Orthic Luvic Gleysol, Gleyed Eutric Brunisol, and Humic Regosol soils. Rhizomull, Leptomoder, and Hemimor humus forms are typical.

Moisture Regime: Mesic - Subhygric

Nutrient Regime: Medium - Rich

Mapping Notes: This unit was relatively dark in tone on aerial photographs.

Assumed Typical Situation: Gentle slopes

Site Modifiers Assumed (from Assumed Typical Situation): j

Modifiers Employed: k, w

Structural Stages: Climatic extremes maintain this unit in the low shrub stage.

Vegetation Notes: The vegetation of this unit is described in Table 41. Willows of this unit include grey-leaved, MacCalla's, and Mackenzie's willows. Sedges include two-toned, brownish, small-awned, poor, Falkland Island, and black alpine sedges.

Photo 44.
Subalpine scrub
SAk3aB
(plot J35)

MA: Entire-leaved mountain-avens - Arctic lupine

General Description: Subalpine scrub/meadow.

Distribution: This unit is typically found on level, crest and upper slope position sites.

Surficial Material: This unit occurs on colluvial, till, glaciofluvial, and weathered bedrock deposits.

Soil Development: Soils associated with this unit include Orthic Melanic Brunisol, Orthic Gray Luvisol, Orthic Gleysol, Orthic Humic Regosol, and Brunisolic Static Cryosol. Humus forms found on sites supporting this unit include Mormoder, Leptomoder, and Rhizomull.

Moisture Regime: Submesic mesic

Nutrient Regime: Poor - medium

Mapping Notes: This unit was medium in tone on aerial photographs.

Assumed Typical Situation: Gentle slopes

Site Modifiers Assumed (from Assumed Typical Situation): j

Modifiers Employed: k, w

Structural Stages: Climatic extremes maintain this unit in the low shrub stage.

Vegetation Notes: The vegetation of this unit is described in Table 41. Willows of this unit include woolly, grey-leaved, Barratt's, and Alaska willows. Sedges of this unit include single spike and small-awned sedges.

Photo 45. Subalpine scrub/meadow MAk3aB (plot K145)

SC

General Description: Subalpine krummholz

Distribution: Rare; restricted to north aspect slopes.

Surficial Material: Occurs on colluvial veneers.

Soil Development: This unit develops on Orthic Gleysol and Orthic Eutric Brunisol soils. Humus forms include Hemimor and Leptomoder.

Moisture Regime: Subhygric

Nutrient Regime: Poor

Mapping Notes: This unit appears dark in tone on aerial photographs.

Assumed Typical Situation: Significant slopes; cool aspects; deep, medium-textured soils

Site Modifiers Assumed (from Assumed Typical Situation): d, k, m

Modifiers Employed: j

Structural Stages: Climatic extremes maintain this unit in the low shrub stage.

Vegetation Notes: The vegetation of this unit is described in Table 41. Willows of this unit include grey-leaved willow.

Photo 46. Subalpine krummholz SCk3aM (plot GS107)

AW: Entire-leaved mountain-avens - Netted willow

General Description: Subalpine meadow

Distribution: Occurs on crest and warm aspect, upper slope positions.

Surficial Material: This unit occurs on colluvial, till, and weathered bedrock veneers.

Soil Development: This unit develops on Orthic Melanic Brunisol soil with Hemimor and Rhizomull humus forms.

Moisture Regime: Subxeric - submesic

Nutrient Regime: Poor

Mapping Notes: This unit is light in tone on aerial photographs.

Assumed Typical Situation: Gentle slopes

Site Modifiers Assumed (from Assumed Typical Situation): j

Modifiers Employed: k, w

Structural Stages: Climatic extremes and dry moisture regime maintain this unit in the dwarf shrub stage.

Vegetation Notes: The vegetation of this unit is described in Table 41. Sedges of this unit include long-styled, small-awned, and Falkland Island sedges.

Photo 47. Subalpine meadow AWk2d (plot GJ32)

Table 41. Ecosystem Units of the SWBmks

		SA3aB	MA3aB	SC3aM	AW2d
SHRUB	average % cover	77	33	60	<1
	white spruce		◦◦		
	subalpine fir	◦◦			
	subalpine fir (krummholz)			◦◦◦◦	
	scrub birch	•••••	◦◦◦◦	◦◦◦◦◦	
	willow	◦◦◦◦◦	◦◦◦	◦◦◦	
	bog blueberry		◦◦	◦◦	
	shrubby cinquefoil		◦◦		
	Labrador tea			◦◦	
HERB	average % cover	44	37	30	53
	Altai fescue	•••	◦◦		
	tall bluebells	••		◦	
	mountain monkshood	••	◦		
	arctic lupine	◦◦	◦◦		••
	sedge	◦◦	◦◦		
	tall Jacob's-ladder	◦◦	◦		◦◦
	bluegrass	◦◦		◦◦◦	◦◦
	mountain sagewort	◦◦		◦◦	
	fireweed	◦◦			
	arctic woodrush	◦◦			
	bluejoint	◦◦			
	northern anemone	◦	◦		
	four-parted gentian	◦			◦◦
	entire-leaved and white mountain-avens		◦◦◦		◦◦
	netted willow		◦◦		◦◦◦
	Lapland rosebay		◦◦		
	alpine bistort		◦		••
	lousewort		•		
	arctic and polar willow			◦◦	◦◦
	lingonberry			◦◦	
	crowberry			◦◦	
	moss campion				••
	spike trisetum				◦◦
	one-flowered cinquefoil				◦◦
MOSS	average % cover	28	36	80	36
	step moss	◦◦◦◦	◦◦◦◦	◦◦◦◦◦	◦◦
	red-stemmed feathermoss	◦◦		◦◦◦◦	
	Aulacomnium turgidum			◦◦◦	
	knight’s plume			◦◦	
	crumpled-leaf moss				◦◦◦◦
	Dicranum elongatum				◦◦
	icelandmoss		◦◦		
	Cladina spp.		◦	◦◦	◦
	Peltigera spp.			◦◦◦	
	Stereocaulon tomentosum				◦◦
PLOTS		B3 B6 J35 GK143 GK146 GS108	K104 K145 W137 GK110 GK175 GS106 GS134 GS135 GS143 GS146 GW140	GS107 GGB08	J33 GJ7 GJ32 GJ41 GK154 GS105

4.6.2 Non-Vegetated and Sparsely Vegetated Units

Table 42. Non-Vegetated and Sparsely Vegetated Units of the SWBmks

Map Unit	Unit Name	Structural Stage	Modifiers Used	Description	Vegetation (where present)
CL	Cliff	1	k, w	A steep, vertical, or overhanging rock face	Unvegetated
GB	Gravel Bar	1	-	Unconsolidated deposits in the active floodplains of small creeks	Scattered vegetation composed of species found in the WY unit
PD	Pond	-	-	Small body of water greater than 2 m deep	Pond edges are generally vegetated with sedges
RU	Rubble	1	k, w	Small angular rock fragments found at the bottom of cliffs or steep rock outcrops; derived from limestone and sandstone bedrock	Usually unvegetated due to slope instability; where rubble is stabilized the sparse herb layer consists of species found in the AW unit

Photo 48.
Cliffs CL1 and rubble RU1 (VJ42a)

4.7 Alpine Tundra (AT)

4.7.1 Herb-Dominated Ecosystem Unit

ML: Moss campion - Limestone sunshine lichen

General Description: Alpine meadow

Distribution: Occurs on crest positions.

Surficial Material: Occurs on rubbly colluvial and weathered bedrock veneers.

Soil Development: Humic Regosol and Orthic Melanic Brunisol soils are typical of this unit. Rhizomull humus form is common.

Moisture Regime: Subxeric - submesic

Nutrient Regime: Poor

Mapping Notes: Appears light in tone on aerial photographs. This unit is difficult to distinguish from unvegetated blockfields (BF).

Assumed Typical Situation: Crest position; gentle slopes; shallow, coarse-textured soil

Site Modifiers Assumed (from Assumed Typical Situation): c, j, r, s

Modifiers Employed: k, w

Structural Stages: Climatic extremes and dry moisture regime maintain this unit in the dwarf shrub stage.

Vegetation Notes: The vegetation of this unit is described in Table 43. Sedges of this unit include single spike, black alpine, and short-leaved sedges.

Table 43. ML: Moss campion - Limestone sunshine lichen

		ML2d
HERB	average % cover	18
	entire-leaved and white mountain-avens	• •
	moss campion	•
	purple mountain saxifrage	•
	netted willow	• •
	alpine bistort	• •
	sedge	• •
MOSS	average % cover	5
	limestone sunshine lichen	• •
	rock worm lichen	•
	icelandmoss	• •
	few-finger lichen	•
PLOTS		B2 K147 S128 S133 GGB01

Photo 49.
Alpine meadow ML2d in the foreground with cliffs CL1 and rubble RU1 in the background (plot K147)

Photo 50. Alpine meadow ML2d (crest of Stone Mountain)

4.7.2 Non-Vegetated and Sparsely Vegetated Units

Table 44. Non-Vegetated and Sparsely Vegetated Units of the AT

Map Unit	Unit Name	Structural Stage	Modifiers Used	Description	Vegetation (where present)
BF	Blockfield	1	-	Level or gently sloping areas that are covered with moderately sized angular blocks of rock derived from the underlying limestone bedrock by weathering and/or frost heave, and that have not undergone any significant downslope movement	Sparse vegetation similar in composition to that of the ML unit
CL	Cliff	1	k, w	A steep, vertical, or overhanging rock face	Unvegetated
RU	Rubble	1	k, w	Small angular rock fragments found at the bottom of cliffs or steep rock outcrops; derived from limestone and sandstone bedrock	Usually unvegetated due to slope instability; where rubble is stabilized the sparse vegetation is similar to that of the ML unit

Photo 51. Block field BF1

4.8 Rare Plants and Plant Communities

No listed rare plant communities were found within the Dunedin study area (B.C. Conservation Data Centre 1996a).

The provincial tracking lists for plants and mosses (B.C. Conservation Data Centre, 1996b, 1998) were used to determine rarity of plants and mosses. Table 45 lists red- and blue-listed species recorded in the Dunedin study area during fieldwork. Identifications of species listed in Table 45 have yet to be confirmed by the B.C. Conservation Centre. There is no tracking list for lichens at this time.

Table 45. Rare Plants and Mosses of the Dunedin Study Area

Scientific Name	Common Name	Global Rank[1]	Provincial Rank[2]	Provincial List[3]	Plots
Vascular Plants					
Astragalus umbellatus?	tundra milk-vetch	G4	S2S3	Blue	GK175, K145
Carex misandra	short-leaved sedge	G5	S2S3	Blue	S128
Leucanthemum integrifolium	entire-leaved daisy	G?	S2S3	Blue	K147
Luzula arctica	arctic wood-rush	G5	S2S3	Blue	B3
Oxytropis maydelliana	Maydell's locoweed	G5	S2S3	Blue	GJ7, GJ32
Polemonium caeruleum ssp. *amygdalinum*	Tall Jacob's ladder	G?T?	S1?	Blue	K43
Rumex arcticus?	arctic dock	G5	S1?	Blue	GK157
Salix petiolaris?	meadow willow	G4	S2S3	Blue	GS152
Salix raupii	Raup's willow	G2	S1	Red	GS42
Saxifraga hieraciifolia	hawkweed-leaved saxifrage	G4	S1?	Blue	GJ32
Mosses					
Hypnum procerrimum		G3G4	S2S3	Blue	W116

1
G2: Imperiled
G4: Apparently secure
G5: Secure
G?: Unranked
G?T?: Infraspecific taxon unranked

2
S1: Critically imperiled because of extreme rarity
S1?: Possibly critically imperiled because of extreme rarity
S2S3: Imperiled because of rarity or rare or uncommon

3
Blue: Vulnerable
Red: Endangered or threatened

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6.0 WILDLIFE INTERPRETATIONS

6.1 Background

At the inception of this project, the list of wildlife species for which detailed habitat-based interpretations were to be made was comprised of the following nine species: Cape May warbler (*Dendroica tigrina*), grizzly bear (*Ursus arctos horribilis*), fisher (*Martes pennanti*), marten (*Martes americana*), Rocky Mountain elk (*Cervus elaphus nelsoni*), mule deer (*Odocoileus hemionus hemionus*), moose (*Alces alces*), Stone's sheep (*Ovis dalli stonei*), and woodland caribou (*Rangifer tarandus*). However, following further research and discussion, it was concluded that there was insufficiently detailed information on Cape May warbler habitat use to permit the refinement of the species model at this time. Consequently, with the agreement of the contract monitor, this species was omitted from further consideration. However, the initial information compiled for this species is provided in Appendix 6 as it may provide some useful background for other studies. Although effort in the report has concentrated on the project species, a list of wildlife species observed during fieldwork is also included as Appendix 7.

6.2 Methodology

6.2.1 Provincial Standards

Species-habitat model structure was based on *Standards for Wildlife Habitat Capability and Suitability Ratings in British Columbia* (RIC, 1997), *Procedures for Wildlife Capability and Suitability Mapping* (RIC, 1997) and on *British Columbia Wildlife Habitat Rating Standards* (RIC, 1998). Each species-habitat model is composed of a species account and habitat ratings. Species accounts for the project species are presented in Section 7.0, and final habitat ratings may be found in Appendix 5 of this report.

6.2.2 Species Accounts

A species account provides background information about the selected species summarizing distribution, life requisites, seasonal use of habitats, limiting factors, and habitat attributes (RIC, 1998). Preliminary species accounts were drafted prior to fieldwork and assisted in identifying habitat features and characteristics of interest to collect information on during the field program.

6.2.3 Habitat Ratings

Habitat ratings were assigned to each of the ecosystem units (or habitats) mapped in the Dunedin study area. Habitat ratings are values assigned to each map unit to express the capability[1] or suitability[2] of that unit to support a wildlife species for a particular life requisite and season (RIC, 1998). They relate the habitat requirements described in the species accounts to the relevant ecosystem attributes (RIC, 1998). They do not take into account non-habitat features, such as the adjacency of other habitats in the surrounding landscape, the proximity of roads, or the location of mineral licks.

Life requisites and seasons that are rated for each of the project species are identified in the species accounts. Ecosystem units were individually assessed for values to the project

[1] Capability is defined as "*the ability of the habitat, under optimal natural (seral) conditions, to provide the life requisites of a species, irrespective of its current habitat condition"* (RIC, 1998).
[2] Suitability is defined as "*the ability of the habitat, in its current condition, to provide the life requisites of a species*" (RIC, 1998).

species, based on the preliminary models, further refined by field observation and data collection. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the species-habitat requirements for the rated life requisites and seasons. Assumptions about the species habitat requirements were developed for each species and were used in assigning the ratings

6.2.4 Preliminary Background Work

Preliminary habitat ratings assigned before fieldwork were limited in scope due to the fact that little work had been done on vegetation classification in the study area. A great many of the units, especially in the SWB and BWBSwk3, had not been described or officially identified and this left a great deal of subsequent work to be done following finalization of the ecosystem classification. Information used in developing the final habitat ratings includes the ecosystem-expanded legend, species accounts, preliminary ratings tables, and wildlife data collected in the field.

6.2.5 Fieldwork

An initial reconnaissance flight made by Gill Radcliffe and Jan Teversham in June 1997 identified field and logistic considerations; key wildlife issues were identified and incorporated early in the planning process. Wildlife fieldwork was conducted in conjunction with the ecosystem mapping/bioterrain work during the two field sampling programs in July and August 1997. See section 2.2. for more information on the field program. Detailed field sampling was designed by the project ecologists with input from the wildlife biologists. During fieldwork, sampling was modified on a daily basis in discussion with all participants, including the wildlife biologists. Every effort was made, within the time and budgetary constraints of the project, to ensure as much wildlife information as possible was collected, as well as covering the range of ecosystem/structural stages and checking for potential wildlife travel routes and mineral licks.

6.2.6 Data Collected

Wildlife habitat assessment forms were completed for all project species at the 63 full ecosystem plots and were also used to record information (for selected species) at the ground inspection plots, which numbered 219. Some of the 756 visual plots also include wildlife notes; 38 of the ground based visuals, and 55 of the aerial visual plots have some wildlife information recorded. Data from full and ground plots was entered into an excel spreadsheet and sorted by subzone/variant and ecosystem for subsequent use in refining the habitat ratings. Visual plot data was also recorded in a separate spreadsheet for ease of sorting. Additional habitat attribute data was collected for this project, including information on wildlife trees and coarse woody debris. Supplementary information was also collected to add further detail on such aspects as arboreal lichen loading and ground lichen availability, which we felt may assist in caribou interpretations. For arboreal lichens, crude estimates were made of lichen loading by using abundant, moderate, sparse and nil categories. For ground lichens, although the vegetation forms give percentage cover estimates, there is no indication of depth/biomass, so lichen depths were noted where relevant to give a crude indication of terrestrial lichen biomass. Notes on phenology, additional adjacency information, or any other features of interest were also made.

6.2.7 Final Species Habitat Models

The species accounts were developed using biological and habitat information published in the literature, personal knowledge, and discussions with species experts. They were subsequently refined using additional data collected in the field. Local knowledge has also been incorporated into the accounts wherever possible.

6.2.8 Digital Map Products

Once the wildlife ratings tables were revised and edited following fieldwork and review, the digital databases were linked via look-up tables to the ecosystem ArcView map files, so that wildlife values could be displayed in ArcView. These digital files are provided as a deliverable for the project. However, a wide range of possible options exists for displaying and analyzing the data, and the client is encouraged to explore ways of improving upon the first iterations that are discussed in section 6.5 of this report.

6.3 Reliability and Data Limitations

For a variety of reasons, many inherent in the habitat mapping process, the habitat rating tables developed for this project should be regarded as a first approximation only. At this point in time, reliability of the ratings for the study area is probably low to moderate, at best, for most species. Factors contributing to the uncertainties that exist are:

- Fieldwork is normally conducted on a one-time only basis. At that time - usually in the summer, as in this case - ratings for other seasons are also being made, but without the benefit of observing actual field conditions at the appropriate times. Inevitably there is therefore a fair bit of guesswork involved in developing ratings for other times of the year. For example, will this site have greened up by late May/early June, or will security cover or food be limited until well into summer? What are typical snow conditions like on this site/slope/aspect in March?. Numerous assumptions and educated guesses are thus involved in generating the ratings, particularly when the study area is relatively poorly described and documented, as is the case for Dunedin.
- There is very little documentation or studies of wildlife habitat associations for this area of B.C. Behavioural ecology of many of the species is not well understood for these northern areas, and information used in developing assumptions is most often based upon studies in different ecological areas. For example, grizzly bear denning needs in this area are unknown, and our expectations of what comprises good habitat is based on studies in the Rocky Mountains further south, and from the coast of B.C. Wherever possible, new research or information was incorporated into the species habitat models to increase reliability.
- Many of the vegetation units were poorly described or not described prior to this project (for example, there are 6 new site series in the BWBSwk3). Our knowledge of these units is thus based on minimal plot data. Habitat ratings are therefore in turn based on a very limited data set; plots may have been done for only one or two structural stages of a given ecosystem unit, for example. Many structural stage variations or variations due to modifiers, such as aspect or slope, are effectively not described. The vegetation assumed for these not described stages/variations is thus an educated guess.
- In the field, habitat ratings for any given unit were often quite variable, reflecting site specific differences, and possibly individual differences between field biologists. Although we try to control for the latter with regular in-house correlation, inevitably there are some differences in how individuals perceive - and rate - the environment. However, between-site variability cannot readily be controlled for. As there is often only a single plot for a given unit, this leads to the situation where the field results may be atypical and may not truly represent more normal conditions for a given unit. The final wildlife habitat ratings have been modified to reflect actual field ratings, so until there is a substantial database for every plot/structural stage/ modifier combination, these ratings may be misleading when field data does not reflect the expectations and assumptions made about the habitat attributes of a given unit. An example in Dunedin is provided by the SW

ecosystem. The SW6C map unit had an average of 20% shrubs, 38% herbs, and 17% tree cover. The structural stage 3 map unit would also be expected to have a fairly high coverage of herbs and shrubs, but the single plot done (in SWb3C) had only 6% shrubs, <1% herbs, and a tree cover of 1%. The revised habitat ratings for ungulate feeding (for example) in this unit are thus very low, while our assumptions would have led to much higher ratings. The plot may or may not reflect typical conditions in the area, and much more data is therefore needed to have confidence in the current ratings.

- Where seasons of use defined are very broad – as in the "growing season" – habitat values are effectively averaged out through the season, which in reality is often difficult to assess and may lead to under or over-rating of certain units in some situations.
- Winter ratings assume average winter conditions, but values can vary substantially from these during mild or severe winters. This could perhaps be accommodated by adding a number of adjustments to the species models to account for different conditions, but would require a lot of knowledge of local climatic conditions and their influence in the study area. For example, one particular aspect for which we have no data but which is likely to greatly influence ungulate winter habitat use in the Dunedin area is information on snowpack.

6.4 Fieldwork Observations

This section presents wildlife observations of interest made during fieldwork. Relevant observations on the key project species are noted in Section 6.5. However, many other species were directly or indirectly recorded during fieldwork, and these are listed in Appendix 7. Noteworthy observations include a pair of trumpeter swans observed on Irene Lake during both the reconnaissance field trip in June, and later during main fieldwork in August. A second pair of trumpeters were observed close to the southern boundary of the study area, in wetlands around McClennan Creek. It seems likely these birds may have been breeding, or may have been attempting to breed, at these sites, although no nests were observed. Overall, waterfowl were not a conspicuous component of the fauna in Dunedin. Only a few duck species were observed, yet Canada geese were observed on a number of occasions, including a group of 15 on Odayin Creek. During the reconnaissance trip, one unidentified duck nest was observed located below a willow shrub in a rich meadow unit. Northern hawk owls were observed in two plots, perched at the interface between open wetland and shrub habitats and mature forest.

Mammals observed, other than the key species discussed below, included black bears observed on several occasions, beavers common throughout the lowland BWBS areas along all main river systems, and squirrels and snowshoe hares, also fairly common. Porcupine sign was occasionally noted, yellow-bellied marmots were observed and heard at the higher elevations, and limited sign of gray wolf was recorded in a couple of locations.

A number of well worn travel routes were observed in the study area leading along ridgetops and main valley bottoms and rivers and through low passes between the foothills and adjacent drainages, for example between the headwaters of the Snake River and the adjacent Toad River. Many of the trails in the foothills appeared to be very heavily used. These are likely used predominantly by caribou and perhaps sheep to travel between seasonal ranges and possibly to mineral licks. Moose, elk, bears, and others will also use these routes for easy travel. Well worn tracks in the northern low-lying areas were less obvious and may be more often attributable to moose use. Possible mineral licks were noted at plots VK142, VK162, VK200, and VK205.

6.5 Summary of Area Values for Key Wildlife Species

For each of the project species, key habitat values within the Dunedin study area are briefly identified. These summaries were made through reviewing the ArcView map files for the study area by species, season, and life requisite. The maps were colored up on the basis of the first ecosystem label only, and no further refinements have been attempted at this stage. Far more detailed and thorough analyses are possible; maps could be colored up by second and third ecosystem components, by some composite ratings through averaging or differential weightings being applied, and so on. However, for simplicity and due to time and budget constraints, we have restricted this brief analysis and overview to the first ecosystem component only. As a first pass, this analysis is therefore a fairly crude representation of the data. Nevertheless, some general trends and values stand out and this section focuses simply on identifying those.

6.5.1 Grizzly Bear

Grizzly bear populations in the study area are believed to be generally low. In June on the reconnaissance, two very lush meadows - prime spring bear habitats - were briefly visited in the north end of the study area. Bear sign was absent at one site, and possible tracks were noted at the other site, but use, if any, was very low. Almost no bear sign was recorded during fieldwork in the northern half of the study area in July. Grizzly bear activity also appears to have been fairly low in the southern portion. At a couple of plots in the foothills including the MA unit of the SWB zone, some sign of bears digging for *Hedysarum* roots was recorded, and a single observation of a grizzly bear was made at the south end alongside the road near 113 Mile Creek (plot VL1). (See Photo 52).

Photo 52. Single observation of grizzly bear near 113 Mile Creek (plot VL1).

Occasional tracks were also noted, but overall there were few confirmed observations of grizzly bear activity. There is some hunting activity by guide-outfitters in this area, but the extent and influence of this on bear populations is unknown.

For grizzly bears, key requirements that are likely to be the most limiting features in the study area are appropriate hibernating habitats and early green up spring feeding habitats. Security habitat for grizzlies (other than in relation to hibernating) while important, especially for females with cubs, is generally unlikely to be a limiting factor in most habitats. Where security may be limiting, e.g., in herbaceous avalanche chutes, the habitats are generally not extensive so security cover is usually available close by. The maps indicate that security habitat is generally widely available throughout in all seasons, although it may be missing from some of the high elevation, open areas in the southwestern corner and some large wetland areas in the BWBS. However, food availability is generally more significant in this area and is the main focus of this discussion.

Spring habitats are likely to be limiting. There are some moderate to high value spring habitats mapped in the northeastern corner of the study area. The WA3 unit has the highest ratings but is extremely limited in areal extent, and occurrence is very scattered. Other high value units are SD6, TB3, and SS2&3 stages, but all are also quite scattered. In reality, many of these units in the BWBS may not become available until later in the spring. More moderate habitats are more widely available, other than along the western ridge and adjacent slopes where bear values are fairly low.

The central part of the Dunedin area has less spring range available with minimal high value habitat but some moderate feeding habitats. This is also true for the southeast section where the BWBS predominates. The southwestern corner supports some of the best spring bear habitats in the area along the warm aspects of the ridges that dominate the landscape in this section. Here, moderately high and high value spring feeding occurs with reasonable frequency in the SK3 and SW5&6 units. A tiny amount of moderately high SHam6 is also mapped. There is little moderate value habitat available here, and about half of the foothills area, in the lower areas between ridges, is generally of very low value.

Summer feeding is unlikely to be limiting in the Dunedin area, and, as might be expected, large areas of good summer feeding habitats are widely distributed. In the northern half, the western rim of the study area appears to have the poorest availability of suitable summer (and indeed, all year) habitats. Some moderately high to high value summer habitats occur in the more mountainous southwestern corner (see Photo 53 following). In this area in the higher elevations of the SWB, important summer feeding units include the SL3, 5&6 units, SW6, and the SK units. Within the BWBS areas, summer habitats such as the AM3 unit are of slightly lower value but are extensively available.

In the fall, good berry crops may be important. Often berry crops are best in mid to higher elevation forests, generally lacking from the northern two thirds of the study area. However, habitats with some moderate potential are very extensively available in the northern two thirds, all through the BWBS. Better habitats (rated 2) are more limited, although they are available, especially in the northeast section of the area where AM5 is frequently mapped. Other units with good berry potential include small areas of LC3 and SHam5, 6, and 7. In the southwestern corner are a few habitats of generally higher value, but they are extremely limited in areal extent. Small areas of SK3&5 are mapped and could be good for fall berries. Otherwise, there is generally low potential for good fall feeding in this part of the study area.

Photo 53. In the southwest part of Dunedin; a mosaic of shrubby, herbaceous, and open forests in the SWB provides good grizzly bear and elk habitats in late spring and early summer.

Good hibernating, or denning, habitat appears to be restricted to the southwestern corner, where the Rocky Mountain foothills offer some potential denning habitats. It is difficult to accurately rate for this attribute as there is no information available on denning requirements in this part of the province. At this time, we have rated the SA3, SW3, and SC3 units as having the highest potential in the area; most of the areas rated high are SC3. Habitats in the SWB, in the southwest corner, are given some moderate to, occasionally, high ratings. Possibly denning would be best on north aspect slopes where more stable snowpack conditions are likely to occur and where early spring green up habitats are available relatively close by over the ridges. This is, however, purely speculative.

We have assumed that the low elevation BWBS units in the northern two thirds would be generally unsuitable for bear denning. However, bears are believed to occur here during the active seasons, albeit in seemingly low densities, and it is unknown how far or where they are traveling to satisfy their denning requirements. Nor is it clear whether the apparent lack of suitable den sites is a factor limiting grizzly populations in this area.

6.5.2 Fisher

No fisher sign was recorded during the fieldwork, and numbers in the study area are thought to be low. As fishers are mobile predators their habitat selection is dictated to some extent by prey habitat selection. Based on the maps, feeding habitats of moderate or better value during the growing season appear to be widely available throughout the area, with the best units concentrated in the northeastern quarter of the study area, and the poorest in the extreme southwest. However, other than in the southwest, feeding habitats are generally available throughout.

Security habitat during the growing season follows a similar pattern to feeding habitat, being very poor in the southwest portion, especially in the SWB and AT, and better in the northeast. Overall security ratings are a little lower than feeding value ratings, and security habitat is likely to be more limiting. A key feature and one that is potentially a significant limiting factor in fisher populations is the availability of suitable reproductive habitat, as this species has fairly exacting requirements for specific habitat features. This has been rated as security habitat during the reproducing season and is the key focus of this discussion.

The maps indicate that, in the northern half of the study area, the most extensive areas of potentially good reproductive habitats are in the northwest with only scattered high (rated 1) but fairly extensive moderately high value (2) habitats occurring. Most of this is accounted for by the AM5,6&7 and SD6 units, and there are very small areas of SHam7 mapped. Other than in these habitats, there appears to be little decent reproductive habitat available; a few scattered areas are rated moderate, but about two thirds of the northern half is rated as very poor. In the southern half of the Dunedin, there appears to be less good habitat available with hardly any polygons rated 1. Moderately high value (2) units occur in a band across the central part of the southern half and also along the ridges in the southwest where there are some scattered high value units, but there is little else. The best units in this area appear to be SW6 in the SWB, and at lower elevations in the BWBS the SHam6 unit appears to be of high value but occurs in just a handful of isolated polygons.

Winter food availability may also be limiting for fisher. Our initial interpretations indicate that winter feeding habitats are generally of low value in Dunedin, except in the northwestern quarter. In this area, quite a lot of moderate and high value winter feeding habitat appears to be available. The southwestern corner appears to have extremely poor availability of winter feeding habitats. Security cover in winter follows a similar pattern.

6.5.3 Marten

No specific marten sign was recorded during the fieldwork. Squirrels, a prime prey item, appear to be present in low to moderate numbers in most of the forested habitats. Overall, marten winter habitat values appear to be quite poor with habitats rated as having no or only low value predominating over most of the study area - probably covering some 80% (based on rating 5 for the dominant site series). Trends in marten habitat values follow a similar pattern to fisher with the highest ratings applied to large areas of AM5&6. The largest expanses of these types occur in the northern and eastern portions of the study area. Values appear to be very low along the western rim, although some scattered good feeding habitats occur in the west towards the southern edge. Large areas of moderate habitat occur in AM4&5 units. The southwestern corner is generally of poor value with low to moderate values predominating in the southeast quarter and throughout the central portion of Dunedin.

Security habitat/shelter for reproduction may be even more limiting. Some moderately good units appear to occur in the southwestern corner, but are otherwise essentially absent in the foothills. Minor low value habitats also occur in the southeastern corner. In the central part of Dunedin, a band with some moderate security habitat occurs. However, as with fisher, the best habitat potential appears to exist in the northeast of the study area. In this corner, moderately rated habitats are quite extensive and some high value habitats also occur. The best values seem to lie in areas of AM7 and SD6, but more widely available moderate habitats include the fairly extensive AM5&6 units.

6.5.4 Rocky Mountain Elk

Elk activity was recorded at a number of locations during the field program. All sign appears to have been recorded in the southern third of the study area with tracks, pellets, and day beds noted in several locations. Elk were also observed on a couple of occasions with an adult feeding in plot VK134 and two adults bedded down in tall shrubs in plot VK135; these sightings were in the BWBS zone close to the Liard highway.

Many of the habitats that provide good feeding also provide adequate security cover. Elsewhere, where security is absent within a unit, it is nevertheless usually available within a reasonable distance. Therefore, feeding is generally considered the most significant consideration, and this discussion focuses largely on feeding values.

During the growing season, the highest quality elk feeding habitats in the study area occur in the southwestern corner where a fair number of high rated units occur, although they are generally small in extent.

Photo 54. Looking north from Plot GB03. This diverse area above 115 Mile Creek receives relatively high summer elk use, as well as high moose use.

In the northeastern quarter, many units are rated high for elk and are more widely available than in the southwest, although overall quality appears to be lower (i.e., rated 2 rather than 1). Many of these units are mesic AM forests of stages 5 & 6, potentially affording both feeding and security cover, although no sign was recorded in these units during fieldwork. Highest potential values are predicted to occur in WA3, SS2&3, and AM3 units. Smaller areas of AM7 also occur, and some units of TB3. There are a very few scattered units rated 1 on the western edge in the northern quarter, and generally fairly low values prevail here.

In the Southeast quarter, there are a few moderately high value polygons, but very little of high value and not very much moderate habitat either. In the south half, the SWB habitats are the best, although good values are absent in the extreme southwest where the most rugged conditions occur. Most of the southwest, however, comprises the foothills where there are many high value habitats for elk including lots of SW3,5&6, SK3, and SL5&6 units. High value SH6 and MA3 units also occur. In the southeast corner in the BWBS, the main units with some elk values are the BL3, SHam5, and AM6 units.

Winter feeding habitats are likely to be a significant limiting factor for elk within the area. Very few units of any value are present in Dunedin. The best units appear to be in the northeast corner where polygons of AM and BK stages 4 and 5 and some SH 6 units along the river occur. In reality, however, these areas may receive no winter use at all. A few isolated polygons of high value occur in the central portion and along the river - mainly riparian SH units of stages 5, 6, & 7. Security habitat may also be more limiting in winter than at other times as the loss of deciduous canopies reduces cover in many habitats. Values are especially low in the southwest. Overall, as security and feeding habitats in winter appear to be in short supply, it seems likely that the general area receives relatively little winter use by elk.

6.5.5 Mule deer

Only a single deer was directly observed in the study area during fieldwork, although deer sign was recorded in a number of places. Some light summer use was recorded in several of the SWB and AT habitats. However, overall the amount of deer sign was very low in all areas of the Dunedin.

Security habitat is likely to be less of a limiting factor in most areas than feeding habitat. Consequently, this discussion focuses primarily on availability of feeding habitats. Although some good feeding habitats (such as some of the sedge-dominated wetlands) do lack security cover, at the present time, adjacent forested units often afford good security. However, security may become more of an issue as the area becomes developed, and should be considered in more depth. More sophisticated analyses of the data should assist in identifying these issues.

Feeding habitats of moderate and higher value are widely available in the growing season. The BS and BL units, widespread in the north, offer generally poor feeding habitat and may be a factor in apparently low populations in the northern portion of the study area.

Winter range availability is generally poor. As for elk, the best habitats in winter appear to be at the northern end of the area, primarily along the main river. Their use at these times is, however, questionable. Overall, very low value winter habitats predominate in Dunedin, although there are a few areas of moderate and higher value scattered throughout. In the southern half, moderate habitat is scattered while very poor winter range again predominates. Security habitat in the winter is also a limiting factor, although again the best habitats appear to occur around the mainstem river in the northern half of the area. In the north-central portion of Dunedin, there is a relatively large concentration of AM7 conifer-dominated forest, which may be relatively important. However, it is likely that, for the most part, the Dunedin study area receives little use by mule deer in the winter months.

6.5.6 Moose

Moose activity was evident throughout the study area, although probably the most abundant sign was in the BWBS. Animals were also observed in various locations throughout the study area. Tracks, trails, pellets, browse sign, and bedding sites were routinely recorded. Animals were most often seen feeding in open wetland SG units and ponds, especially along the edges of the Dunedin Torpid, and Odayin rivers. Most notable were a relatively large number of sightings in the wetland complexes around Irene Lake and along Torpid Creek. Up to six moose were seen in this area on successive days; males appeared to forage more in the open with cow and calf combinations around the perimeter of the wetlands close to more shrubby areas.

Photo 55. Wetland complexes around Irene Lake and Torpid Creek provide excellent growing season habitat for moose.

Photo 56. Bull moose observed foraging in sedge wetland by Torpid Creek.

A number of shed moose antlers were also observed in the study area, usually in the scrub birch/willow shrublands in the SWB zone, but also in the wetlands in the BWBS.

In general, security habitat is unlikely to be limiting for moose in the study area. Although it is lacking in the large open ridges in the southwest corner of Dunedin, it is otherwise quite available throughout, so feeding values have been selected as the main focus for discussion.

Feeding habitats for moose, spread throughout the study area, are quite widely available in the growing season. Proportionately, the northeast affords some of the most extensive areas of high value, but there is still considerable representation through the southern half of the area. The western edge in the northern half appear to generally support the lowest feeding values. Some of the best feeding habitats scattered in the BWBS include SS2&3, AM3&5, and TB3 units. Quite extensive areas of moderately high value (2) habitats occur in the northeastern quarter and on both sides of the Dunedin mainstem. For example, fairly extensive areas of SS3a and 3c occur around Irene Lake and along Torpid Creek.

In the southwest of the study area, moderately high and high value units are less extensive but still quite plentiful. In the higher elevations of the SWB, good summer feeding occurs in SL3, SA3, and SB5&6 units, all rated 1. High values also occur in the SW6 and SL5 units. The southern and eastern quarters of Dunedin support generally slightly lower values; although, there is still plentiful moderate habitat available in the BWBS, but really good habitats are not widespread nor extensive.

Winter food availability is likely much more limiting. The northeast offers the best potential winter habitats with extensive AM5 available. Other high value units are WA3, AM4, SS3 and BS3. SH units are important riparian units with high winter values available along the Dunedin River mainstem in the lower half of the study. The southwestern corner of the study area, in the foothills, has very little good winter habitat mapped. Values in the southeast corner, dominated by the BWBS, are generally moderate. Security ratings are similar with a fair bit of good habitat in the northeast and generally moderate values through the rest of the area, although ratings are very poor in the southwest sector. Based on habitat, it seems likely there will be more moose wintering in the northeast of the Dunedin area than in the southern part, although some may occur in the southeastern lowlands areas.

6.5.7 Stone's Sheep

Stone's sheep were observed in small groups on a number of occasions during the fieldwork, and scat was abundant in a number of the high elevation habitats in the southwestern corner of the study area. Observations were usually of individuals or small groups of 4 to 6 sheep comprising mixed adult/juvenile groups. On one occasion, a single ram was recorded on top of Stone Mountain. The sheep were observed in high, open meadows near to cliffs and on escape terrain comprising unvegetated broken cliffs with many small ledges. All occurrences within the study area were in the most rugged parts of the area, in and around Stone Mountain and the adjacent ridges. Sheep pellets were abundant in many of the open meadows in this area. Groups of Stone's sheep were also seen traveling down washes and alongside the roads near to the study area boundaries where they were traveling to obtain mineral salts from the roadsides or were perhaps en route to other mineral licks.

The only good sheep habitats in Dunedin at any time are concentrated in the southwestern corner of the study area (on the bottom four mapsheets) in the relatively rugged mountains near the southern periphery.

Photo 57. Stone's sheep at edge of Liard Highway near Dunedin study area.

The best habitats occur in the rugged terrain of Stone Mountain itself and the adjacent ridges and slopes. All of the highest values occur in the southwest in the SWB and AT zones. Highest rated units in the growing season for food are the MA3 and ML2 units, followed by the SA3 and SL units. These occur all along the ridges running northwest to southeast.

Photo 58. Plot VK105; typical Stone's sheep summer feeding habitat in Dunedin.

Warm aspect units are especially valuable. A fair bit of moderate feeding habitat is available in SL5, SW5, BK3, and SK3&5 units. All areas north of the foothills are rated as very low to nil for feeding with just a few scattered polygons with moderate ratings. These latter are, however, unlikely to receive much if any use due to their isolated locations and distances from good escape terrain.

Security habitat in the growing season is in reality very limiting, and all of the best units occur in the southwestern corner where cliffs along the ridges provide ideal escape terrain.

Photo 59. Typical escape terrain. Sheep were observed using the broken ledges in photo center for escape terrain and the meadows on top for feeding.

CL and RU units have the highest ratings with some ML2 units also of value for security. Security habitat is clearly limiting in availability and should be examined in conjunction with the feeding habitat information to identify the best areas for sheep.

In winter, feeding habitats are generally poor throughout, and most of the Dunedin has low or no winter values. Winter security habitat is similar to in the growing season, so feeding at this time may be more of a factor in determining sheep ranges. The only winter habitats identified are concentrated in the extreme southwestern corner where MA3 and CL1 units are identified as having some winter values.

6.5.8 Woodland Caribou

During the reconnaissance trip in June, small groups of caribou were observed on a number of the ridges in the Rocky Mountain foothills in the southwest corner of the study area. Sightings on that date comprised 3 separate groups of 3 animals, 1 group of 5 animals, and a group of 11. These animals were traveling across the meadow dominated slopes in the foothills area north of Stone Mountain or were lying on small remnant patches of late-lying snow on the cool, north sides of the ridges, presumably for relief from insects and heat. High caribou use of a number of stops was noted with numerous pellets including numerous tiny pellets recorded on some SWB ridge tops, suggesting birthing may occur. Caribou antlers were observed in a number of locations in the SWB in birch scrub and willow sedge habitats close to the open meadows. During the main field trip in August, small numbers of caribou were seen up in the alpine and also down alongside the Trans Canada highway near the study area, and one was observed swimming south across a lake along the highway.

Habitat values for the northern ecotype of woodland caribou for the northern two thirds of the Dunedin area are very low or nil for all seasons. The extensive plains of BWBS that predominate over the northern part of the study area may, however, support low numbers of the boreal ecotype, which have different habitat requirements. The distinction between populations in this area is very unclear. For northern caribou, however, habitat values are effectively concentrated in the southern and especially the southwestern portion of the area, i.e., the foothills and immediately adjacent areas.

Photo 60. Woodland caribou alongside highway in the Dunedin study area.

Reproduction (birthing) is believed to occur on a number of the long ridges, and evidence of relatively high use by adults and young was observed during the reconnaissance. Highest value habitats, providing both reasonable feeding and some security (in the form of relatively high elevations and high visibility for detecting predators) during reproducing are probably the MA and SA stage 3 units (deciduous) and the ML stage 2, which occur on the ridges in the southwestern corner. Security and feeding values of habitat elsewhere is usually extremely low to nil, although there are some areas rated as moderately high for feeding in the northeast. However, more information on caribou use of the area and of the overlap/interaction between northern and boreal ecotypes is needed to improve the species model predictions.

Early winter habitats are fairly available in the southern part of the area, where a mosaic of low to moderately high value habitats occurs. Reasonably good habitats at this time include the BS3 and the ML2 units. However, as winter progresses, available habitats are likely to become more limiting, and deep snow may prevent access to food in many areas. However, the lack of local snowpack information limits the interpretations that can be made here. Overall, pine stands with good ground lichen availability appear to be extremely limited in the Dunedin area. Consequently, late winter habitats are very poor with some moderate habitat located in the southwestern portion comprising MA3 and ML2 units only.

Far more information on local conditions and herd movements is required before the habitat interpretations can be considered anything more than preliminary in nature. It is certainly possible that the caribou breeding in the area also winter in some of the forested BWBS areas as well as in higher elevation SWB forest stands, and winter range management will need very careful future attention in this regard.

6.6 Wildlife Interpretations References

Resources Inventory Committee. 1998. *British Columbia Wildlife Habitat Rating Standards.* Review Draft, April, 1998. Wildlife Interpretations Subcommittee, Wildlife Branch, Ministry of Environment Lands and Parks, Victoria, B.C.

Resources Inventory Committee. 1997a. *Standards for Wildlife Habitat Capability/Suitability Ratings in British Columbia*. Review Draft, May 18, 1997. Wildlife Interpretations Subcommittee, Wildlife Branch, Ministry of Environment Lands and Parks, Victoria, B.C.

Resources Inventory Committee. 1997b. *Procedures for Wildlife Habitat Capability and Suitability Mapping.* Partial Draft, August 1, 1997. Wildlife Interpretations Subcommittee, Wildlife Branch, Ministry of Environment Lands and Parks, Victoria, B.C.

SPECIES-HABITAT MODELS

7.0 SPECIES - HABITAT MODEL FOR GRIZZLY BEAR

Common Name:	**Grizzly Bear**
Scientific Name:	*Ursus arctos horribilis*
Species Code:	M-URAR
B.C. Status:	Blue-listed (B.C. MoELP, 1996; B.C. Conservation Data Centre (CDC), 1997)
Identified Wildlife Status:	Yes (B.C. MoELP, 1997)
COSEWIC Status:	Designated as vulnerable in Canada, following a review by Banci (1991) (COSEWIC, 1997).

7.1 Introduction

The information presented in this species-habitat model has been largely extrapolated from other regions as there is little documentation of grizzly bear habitat associations for this part of British Columbia. There have been no specific grizzly bear habitat studies or inventories completed within the Dunedin study area nor in northeastern B.C. (B. Webster, L. Wilkinson, *pers. comms.*). At this time, general habitat ratings for the grizzly bear for the Dunedin study area are predicted to have a low reliability as no model verification has been done. Before more reliable ratings of habitat value can be developed, data is required on the seasonal food habits and habitat selection of grizzly bears in this region.

A grizzly bear study began in May 1998 in Prophet River (to the southeast of the Dunedin study area) and should provide some information on grizzly habitat use in this region (B. Webster, L. Wilkinson, *pers. comms.*).

7.2 Distribution

The traditional range of the grizzly bear throughout most of central and western North America has been dramatically reduced during the last century (Banci, 1991). Presently this species occurs in the western United States (Alaska, Wyoming, Idaho, Montana, and Washington) and in northern and western Canada (Alberta, British Columbia, Northwest Territories, and Yukon Territory) (Lefranc *et al,* 1987).

7.2.1 Provincial Range

Grizzly bears inhabit most of the mainland portion of British Columbia except areas that have been urbanized or intensively farmed or used for ranching (Hamilton, 1989). The latter include the lower mainland, Thompson-Okanagan, Cariboo, and Peace River areas (Fuhr and Demarchi, 1990). The British Columbia population of grizzly bears is estimated at 10,000 to 13,000 bears (B.C. MoELP, 1997; Fuhr and Demarchi, 1990). Fox (1987) estimates that approximately 9,000 or 72% of the provincial grizzly bear population is found throughout the Northern Region: 4,700 in the Skeena, 1,500 in the Omineca, and approximately 2,800 in the Peace sub-region.

The British Columbia grizzly bear population can be described as two distinct ecotypes; coastal and northern interior (Hamilton, 1997). Coastal mountain studies indicate that grizzly bear habitat occurs predominantly below tree line, concentrating on ecosystems associated with important salmon rivers (Banner *et al.,* 1985). The northern interior grizzly bear ecotype occurs where there are no salmon bearing watersheds. These bears use a range of habitat types from forested valleys to alpine and subalpine ecosystems (Banner *et al.,* 1985;

Mosquin and Suchal, 1977). An "ecological gap" exists in the Sub-Boreal Interior and Northern Boreal Mountains of British Columbia (Hamilton *et al.,* 1997) and in the Taiga Plains ecoprovince (T. Hamilton, *pers. comm.*) as no studies have examined the habitat use and ecology of grizzly bears in these ecosystems (Hamilton, 1989). At present, a study has just been initiated (Northern Rockies Grizzly Bear Project) to view and understand the ecology and viability of grizzly bears in the Central Rocky Mountains of British Columbia (G. Watts, *pers. comm.,* 1998). Some important findings from coastal studies have been included in this summary, yet the habits of the interior grizzly bear will be the focus of this species account.

On a provincial basis, relative abundance of grizzly bears is rated as moderate over most of the Dunedin study area (1 grizzly per 65 km^2 to 140 km^2) (Fish, Wildlife and Habitat Protection Department, 1994). Grizzlies are found within all of the ecoregions, ecosections, and biogeoclimatic zones found within the Dunedin study area, as summarized in Table 46.

Table 46: Expected Grizzly Bear Occurrence within the 6 Ecosection/BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	**TAIGA PLAINS**		**NORTHERN BOREAL MOUNTAINS**			
Ecoregions	**Muskwa Plateau**		**Northern Canadian Rocky Mountains**			
Ecosections	**MUP**		**MUF**			
BEC Variants	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**SWBmks**	**AT**
Species						
Grizzly Bear	•	•	•	•	•	•

Legend:
- = occurs in the variant

7.2.2 Elevational Range

Within the study area, grizzly bears are found from the BWBS zone up to the AT zone (approx. 250 m to 2105 m).

7.3 Ecology and Habitat Requirements

The grizzly bear has extensive spatial requirements and uses a diverse range of ecosystem types to meet its life requisites (Hamilton, 1989). As apex predators with conservative reproduction and low resilience to human disturbance (Weaver *et al.,* 1996; Hamilton, 1989), grizzlies are indicators of ecosystem health. The presence of grizzlies indicates that all other trophic levels of the ecosystem are intact (Gibeau *et al.,* 1996; and White *et al.,* 1995). Grizzly bear requirements for large expanses of continuous wilderness containing abundant food make them very susceptible to habitat fragmentation and human encroachment (B.C. MOELP, 1997; Gibeau *et al.,* 1996). Population recovery or resilience is inhibited by a late age of first reproduction, long inter-litter periods, and a low survival rate for cubs (Wielgus, 1986; Miller *et al.,* 1982).

Social interactions between individuals are important factors determining habitat use (B.C. M)ELP, 1997). They are discussed briefly here to further clarify the ecology of the grizzly bear, but they are not included in the ratings tables as they are considered non-habitat features.

Home range size and location is influenced by sex, age, and reproductive status of animals. Size and location of home ranges also vary with population density and habitat quality (Nagy and Gunson, 1990). Adult male grizzly bears are the most mobile of the sex and age groups (Pearson, 1975; Miller *et al.,* 1982), and male home ranges are larger than those of females or sub-adults. Male requirements range from 916 km^2 in Jasper to 24 km^2 in the Karluk Lake area (Lefranc *et al.,* 1987). Male ranges in the northern interior averaged about 287 km^2 (Pearson, 1975), but estimates suggest that home ranges for males in interior ecosystems may range from 1000 km^2 to 2000 km^2 (Gibeau *et al.,* 1996; Russell *et al.,* 1979). Adult females show more fidelity to specific home ranges, and average range sizes for these bears in the Mackenzie Mountains of the Northwest Territories was 265 km^2 (Miller *et al.,* 1982). This range size is larger than that reported by Pearson (1975) who found 86 km^2 in southwestern Yukon and 73 km^2 in northern Yukon for females (Pearson, 1976). Although female ranges do not commonly overlap (excepting between daughter and mother), sub-adult and adult male ranges commonly overlap female ranges.

The sexual segregation among grizzly hears (Weilgus and Bunnell, 1994) forces females to use higher elevations, different aspects, and steeper slopes when males move into female ranges. Compression of male home ranges may indirectly lead to displacement of females from more high quality food sources. It is suggested that females move into less productive habitat in order to avoid adult males, particularly in the fall when males converge on highly productive berry patches (Weilgus and Bunnell, 1994).

Reproduction rates are low among grizzlies as first age of reproduction ranges from age four upwards, and litter sizes range from one to four (1.4 to 2.5 average) (B.C. MoELP, 1997). Bunnell and Tait (1981) found that litter size was negatively correlated with latitude, and Pearson (1975) suggests that age at first reproduction may vary with latitude and nutritional status. Some studies at more northern latitudes have found relatively larger litter sizes (e.g., Ballard *et al.* (1993) recorded an average litter size of 2.17 cubs per female in north-western Alaska). This higher relative litter size was attributed to an abundance of marine mammal carrion and salmon. Miller *et al.* (1982) found a mean litter size of 1.83 cubs per female in the Mackenzie Mountains, Northwest Territories. Pearson (1975) found a mean of 1.6 young per litter in the Kluane Range.

Cubs remain with the mother from the time of birth in the winter den until they are between 26 to 28 months old (B.C. MoELP, 1997). The average litter interval is three years with a minimum inter-litter period of three years in the Kluane National Park.

7.4 Habitat Use (Life Requisites and Seasons)

Grizzly bear habitat use for the study area is broken into spring, summer, fall, and winter seasons. Life requisites that are rated for the grizzly bear include living, hibernating, feeding, and combined security/thermal, as summarized in Table 47.

Table 47: Summary of Rated Life Requisites and Seasons for Grizzly Bears in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use*	Period Covering
Living during the spring season - food Living during the spring season - security/thermal	LI_P_FD LI_P_ST	April to late-May	- Early spring period - Emergence from dens to full leaf flush (season of scarcity - food resources are few and far between, few ecosystems of value and few plants of value)
Living during the summer season - food Living during the summer season - security/thermal	LI_S_FD LI_S_ST	June to mid-August	- Late spring-early summer period - Full leaf flush to berry ripening - Feeding mainly on vegetation
Living during the fall season - food Living during the fall season - security/thermal	LI_F_FD LI_F_ST	Mid-late August to September (until denning)	- Late summer-fall period - First berry ripening to time of denning (season of plenty)
Hibernating	HI	October to late March-April	- General areas of denning - Birth of cubs

*Please note the months of these seasons do not correspond with those suggested for these ecoprovinces in RIC (1998). Rather, they have been modified to more closely reflect the seasonal food habits of the grizzly bear for this region of British Columbia (based upon communication with T. Hamilton, Wildlife Branch, Victoria).

For the species model, differentiation between security and thermal values is not included because security habitat meets most thermal requirements. Rated life requisites are described in detail below. Additional information on reproduction is also included, although this requisite has not been rated. Reproducing (birthing) habitat is assumed to be the same as hibernating habitat as young are born in the winter dens.

7.4.1 Living

Grizzly bears use a variety of habitats in B.C. from coastal estuaries to alpine meadows (RIC, 1997c). In each of these different biomes, the grizzly encounters "grossly varying conditions not only in terms of availability of food but also in terms of denning sites and other physical requirements for its existence and successful reproduction" (Pearson, 1977:35). The grizzly bear requires extensive space (Nietfeld *et al.,* 1985) and uses a diverse range of ecosystem types to meet its life requisites (Hamilton, 1989). As indicated by habitat use, forage patterns follow seasonal food availability. In the early spring, bears follow the phenology of the high-value early herbs and move into the higher elevations with early green-up usually near denning sites. Bears move to lower elevations in the early summer as berries ripen, then gradually move back to higher elevations as the summer progresses using later ripening berries and other foods to put on fat stores required for winter survival.

7.4.2 Feeding

Grizzly bears are omnivorous and have a diverse diet including vegetation, berries, carrion, small and large mammals, fish, and insects. During all seasons, grizzlies will opportunistically take ants, ground squirrels, and young or weak ungulates (Miller *et al.,* 1982). Studies have found that food use varies seasonally (Miller *et al.,* 1982; Pearson, 1975), and season of use varies regionally according to different provincial ecotypes (Fuhr and Demarchi, 1990). Season of use will also vary annually as grizzly food use will follow the phenology of their particular area, and the bears will seek out the highest value food sources according to emergence and maturation of plants (Fuhr and Demarchi, 1990; Miller *et al.,* 1982).

Spring Season

In early spring at den emergence, food is localized and generally scarce. During this time, bears may frequent ungulate wintering grounds feeding on carrion and opportunistically preying on winter-weakened ungulates (Nagy, 1990; Nietfeld *et al.,* 1985). In many areas, hedysarum roots are important in the early spring as are over-wintered berries (crowberries and bearberries), corms of the spring beauty, and corms of glacier lilies (Miller *et al*., 1982; McCrory and Herrero, 1983). As green vegetation emerges, grizzlies will feed on the succulent early growth stages including grasses, horsetails, rushes, and sedges (RIC, 1997c). In late spring, bears will frequent warm aspect avalanche tracks and meadows where the vegetation is first exposed, usually at lower elevations (Gibeau *et al.,* 1996; T. Hamilton, *pers. comm.*; Hamilton, 1989). In Alberta, Kansas and Riddell (1995) found the most important vegetation sites in April are characterised by sub-xeric moisture conditions and coarse-texture soils occurring on south and west facing steep slopes in the lower Montane and lower Subalpine ecosystems. Steep south-facing river slopes with grassy areas are important foraging areas in early spring (T. Hamilton, *pers. comm.*).

Summer Season

Green vegetation (particularly graminoids, horsetails, cow-parsnip, and forbs) form an important part of the late spring and early summer diet. These foods are probably most available in riparian areas and seeps (subhygric and hygric sites) that produce high densities of prime summer vegetation and in run out zones on south facing avalanche chutes (Hamilton, 1989; McCrory and Herrero, 1983). Kansas and Riddell (1995) found that important sites used in May and June occurred on fluvial landforms and alluvial fans on the lower slopes of steep south aspects characterised by aspen and balsam poplar forests, spruce/horsetail forests, and/or wet shrub thickets. On higher elevation avalanche slopes, bears feed on spring beauty, glacier lily, valerian, grasses, and sedges (Eastern Slopes Grizzly Bear Project, 1997; Hamilton, 1989). Grizzly bears will continue to forage on horsetails into late June at lower elevations and will also prey on ungulates on their calving grounds. By about mid-July, soopolallie berries become ripe (Hamilton, 1989) and are thought to be an important early berry food in northeastern B.C. (T. Hamilton, *pers. comm.*).

Fall Season

Berries form a very important component of the bear's diet during late summer and fall. Use of alpine habitat is significantly reduced in late summer and early fall as bears move down into the lower elevations where berry and root production are the highest (Miller *et al.,* 1982). Hamilton (1989) suggests that in the fall bears will be found in a wide diversity of habitats supporting berry and root production. Important fruit producing shrubs include soopolallie, huckleberry (important during August and into September (Hamilton, 1989), high-bush cranberry, Saskatoon, choke cherry, currants, bearberry, and crowberry (Nietfeld *et al.,* 1985).

Grizzly bears were found to depend heavily on soopolallie in Kananaskis Country, Alberta (Wielgus and Bunnell, 1994) to put on fat stores for the winter. Hamilton (1989) found soopolallie to occur in large burns and along active floodplains, and, although these berries were observed in riparian spruce stands, berry production seemed higher in more open canopies. Nine of ten soopolallie sites in the Rocky Mountain front ranges were found in the Montane ecosystem (Kansas and Riddell, 1995). In addition to berries, grizzly bears will return to digging hedysarum roots (common on floodplains) and will feed on ants and wasps (Hamilton, 1989). In years when berry crops fail, bears switch back to green vegetation sites and use of roots intensifies (Pearson, 1975).

7.4.3 Hibernating (Denning)

Denning for pregnant females may begin as early as October 1, while other bears will den in November within the northern interior region of British Columbia (Hamilton, 1989). Grizzlies generally den in higher elevation talus slopes, shrub-fields, krumholtz areas, or timbered subalpine areas with stable, deep, snow packs and relatively slow snow melt (Vroom *et al.,* 1980; Vroom *et al.,* 1977; RIC, 1997c). Dens are often right at the edge of the tree line at the transition to alpine ecosystems (D. Becker, *pers. comm.*). Dens are generally excavated into steep slopes (deeply bedded soils when available that are well drained and cohesive) or they may be in natural caves or hollows under the roots of trees (RIC, 1997c). Often, an initial den site may not be adequate, and bears will try excavating other den sites until a suitable site is found (D. Becker, *pers. comm.*). Den sites are often located on slopes ranging from 25° to 40° with a predominately southeastern orientation (leeward of prevailing winds) (Miller *et al.,* 1982; Nagy, 1990; Pearson, 1975; Vroom, 1977). Dens in the Banff area generally collapse on an annual basis so are not reusable (Vroom, 1977).

Denning requirements have not been researched for the boreal forest of British Columbia; however, it appears that elevation and adjacency of suitable spring foraging habitats may play a role. Areas of suitable denning may be very restricted within the northern part of the Dunedin study area due to lack of denning sites, which generally comprise high elevation areas on slopes with stable, deep, snow packs (Vroom *et al.,* 1980; Vroom *et al.,* 1977; RIC, 1997c).

No exact den emergence times are available, and grizzly bear emergence may vary annually. Emergence for an adult male in the Mackenzie Mountain area, Northwest Territories, occurred during the first week of May; although females with cubs were not observed until mid-May (Miller *et al.,* 1982). In the Mackenzie area of B.C., Hamilton (1989) suggests that male grizzlies would probably emerge from their dens in early April, females alone or with yearlings and older offspring would probably emerge in late April, and females with cubs would remain in dens until late May. Grizzlies in Banff den sometime in November and emerge about early April (Vroom *et al.,* 1977).

7.4.4 Security Habitat

Understanding of grizzly use of habitat for security is limited, literature references are inconsistent, and no studies have been done specifically testing grizzly reliance on cover in the northern interior ecotype. Nietfeld *et al.* (1985:97) assume that "security cover is most likely not a limiting factor in wilderness areas" with the exception of areas of resource development (dependent upon the amount and type of access – permanent, temporary, or seasonal) such as logging and oil and gas exploration with associated road construction.

Grizzlies use a variety of different cover types for escape cover including vegetation and/or topography having a diameter of at least 91 m and able to hide 90% of a grizzly from view of a person 122 m away (Zager *et al.,* 1980, as cited in Nietfled *et al.,* 1985). Requirements for security cover may vary between hunted versus unhunted populations with open habitats being used more for foraging by the latter while hunted populations may use areas with relatively high cover. Importance of security cover in hunted areas is increased according to Mattson (1993) as cited in Gibeau *et al.* (1996). McLellan (1985) suggests that even if timber is not mapped as grizzly habitat, it should be noted particularly in relation to other selected habitats. Servheen (1981) suggested that bears rely on darkness for cover and will forage and travel under cover of darkness in habitat where security is low. Hamilton (1987) found that bears on the coast (Kimsquit River) preferred to be in cover, possibly to avoid other bears.

Cover use varies with female reproductive status (Lefranc *et al.,* 1987). Females with young often select rugged, isolated habitats and will avoid habitat more commonly used by other conspecifics, particularly males. Pearson (1975) observed sows with cubs to use rock and snow zones as refuge.

7.4.5 Thermal Habitat (Bedding)

Bedding is an important activity throughout the growing season. Grizzly bears will often rest between bouts of feeding particularly to avoid the heat of the day, and daybeds are therefore often in timbered areas near feeding sites. During warmer summer temperatures, bears will often dig beds in patches of remnant snow or in soil under closed canopies provided by forest cover or high shrub.

Thermal cover will be required by bears during warm periods in spring and summer to reduce body temperatures and during periods of heavy rain to remain drier. Methods of cooling include bedding in snow patches and excavated soil beds and bathing in streams and springs. Dry habitat types like older forest patches with closed canopies and rock overhangs will be used to intercept rain (Hamilton, 1989).

7.4.6 Reproduction

Although little information is available on the habitat requirements for mating activities in the northern interior, mating areas in Banff National Park included isolated mountain summits or upper-elevation ridges (Hamer and Herrero, 1990). The copulation period of grizzly bears is from approximately late May until mid-July, and implantation of the fetus is delayed (B.C. MoELP, 1995). In the northern Yukon, Nagy (1990) found the copulation period to be from mid-May to mid-July with the most paired adults observed between late May and late June. The breeding period is from April to June in the Mackenzie Mountains, Northwest Territories, according to Miller *et al.* (1982). Between January and March, cubs are born in the den (B.C. MoELP, 1995). Den characteristics are important to provide favourable conditions for birthing and early survival of cubs.

7.4.7 Seasons of Use

Table 48 summarizes the rated life requisites for grizzly bear for each month of the year.

Table 48: Monthly Rated Life Requisites for Grizzly Bear in the Dunedin Study Area

Month	Season	Rated Life Requisites	Estimated Time Period
January	W	HI	
February	W	HI	
March	W	HI	
April	P	LI-FD, ST or HI	Emerge around April to mid-May
May	P	LI-FD, ST	
June	S	LI-FD, ST	
July	S	LI-FD, ST	
August	S, F	LI-FD, ST	
September	F	LI-FD, ST	
October	F, W	LI-FD, ST or HI	May den as early as October 1 or as late as October 31.
November	W	HI	
December	W	HI	

Legend
W=Winter P=Spring S=Summer F=Fall HI=Hibernating LI=Living FD=Food ST=Security/Thermal

7.5 Habitat Use and Ecosystem Attributes

Table 49 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 49: Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for Grizzly Bear

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	Slope, aspect, elevation, structural stage, % cover of low shrub, herb cover, herb species composition, shrub species composition, soil depth
Living Habitat (Security/Thermal)	% cover trees and shrubs, height of shrubs, microtopography, riparian or water substrate
Hibernation	Availability of secure den sites, elevation, slope, aspect, prevailing winds, bedrock, terrain texture, flooding regime, soil texture and depth, drainage

7.6 Development of the Habitat Ratings

7.6.1 Rating Scheme

A 6-Class rating scheme of high (1), moderately high (2), moderate (3), low (4), very low (5), and nil (6) is employed (as suggested for grizzly bear by RIC, 1998) and requires a substantial knowledge of habitat use (Table 50).

Table 50: Habitat capability and suitability 6-class rating scheme (from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	1
75% - 51%	Moderately High	2
50% - 26%	Moderate	3
25% - 6%	Low	4
5% - 1%	Very Low	5
0%	Nil	6

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for the grizzly bear, as previously outlined in Table 47.

7.6.2 Provincial Benchmark

The provincial standard (best in B.C.) for the interior grizzly bear is the BRR ecosection within the Southern Interior Mountains ecoprovince (RIC, 1998). The two ecosections (MUP and MUF) found within the Dunedin study area each have a moderate (26% to 50% of standard) capability compared to the standard (RIC, 1998). Overall, the Dunedin study area is expected to have a moderate capability for grizzly bear.

As a smaller scale reference, the Northeastern British Columbia Biophysical Overview Mapping project has assigned grizzly bear habitat capability ratings for the ecosection/BEC variant combinations found within this region (Table 51) (Habitat Inventory Section, 1994).

Table 51: Ecosection/BEC Variant Combinations for Grizzly Bear
Class values for habitat capability mapping of northeastern B.C.
(Habitat Inventory Section, 1994)

Ecosection	**MUP**		**MUF**		
Variant	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**AT**
Species					
Grizzly Bear	3	3	2	3	3

Legend
6-class rating scheme: Class 1 - high, Class 2 - moderately high, Class 3 - moderate, Class 4 - low, Class 5 - very low and Class 6 - nil.

The SWBmks was not rated in this study; T. Hamilton speculates that this variant would probably be Class 2 (T. Hamilton, *pers. comm.*).

7.6.3 Ratings Assumptions

Habitat ratings tables for the grizzly bear are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the grizzly bear's seasonal requirements for feeding, security, and hibernation. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 49) to meet the requirements. The following assumptions have been made:

- Feeding values were assigned on the basis of availability (presence, percent cover) and timing of seasonally important food species as described in the feeding section. In general, structural stage 1 has poor foraging value as it is mainly unvegetated. Stage 2, 3a, and 3b are used throughout the growing season with stage 2 receiving more use in the spring and summer and stage 3a and 3b receiving more use in the summer and fall. Structural stages 6 and 7 are used in early summer through to the fall. Riparian areas and other ecosystems with preferred herbs are rated high in early spring as these areas should provide abundant, new succulent forage. Units with preferred species of herbs are rated highly in the defined summer period, and units with berry-producing shrubs are rated high in the defined fall period. Fire influence will increase berry production.

- Units in the SWBmks and AT have poor foraging values in the spring due to the increased snow depths at these higher elevations. Lower elevations should provide the first available green vegetation; meadows, warm aspect avalanche tracks and slopes where the vegetation is first exposed are very important spring feeding sites, and therefore rated highly, during this season.
- The Tall Jacob's ladder - Bluejoint (JB) unit in all biogeoclimatic zones and the BWBSmw2 Ac - Alder - Horsetail ecosystem unit, "pa" seral association (SH:pa), were given lower food ratings in the spring as they were assumed to have delayed phenology due to spring flooding.
- Understory characteristics including shrub composition, height, and density determine the value of units as security habitat. Units with a very sparse understory generally provide low security cover. Coniferous shrubs provide better visual screening than deciduous shrubs in spring. Larger trees provide better security as will more CWD and structural diversity. Stage 3a units provide moderate security cover if vegetation is tall enough to screen standing grizzlies. Stage 3b forests should generally provide good security cover as will most units with dense shrub understory.
- Security habitat ratings are significantly less important than food ratings throughout the growing season.
- Grizzly bear hibernating requirements are not known within the BWBS biogeoclimatic zone for this area of British Columbia. Grizzlies generally den in higher elevation areas with stable, deep, snow packs and relatively slow snow melt (Vroom *et al.,* 1980; RIC, 1997c) which are not present within this zone. Wet units were given a rating of 6 as they are unlikely to provide suitable denning sites. Mesic units may have some potential for denning, therefore they were given a 4 until more is known about denning requirements.

7.6.4 Rating Adjustment Considerations

Grizzly bear habitat is fragmented by forest harvesting, fire suppression, and increased human development and settlement (B.C. MoELP, 1997). Habitat loss beyond large scale physical loss of habitat was found to include "loss of security, which is being triggered primarily by development, increased human use levels, and a known negative response of grizzly bears to sensory disturbance" in Banff National Park (Gibeau *et al.,* 1996:43). Grizzly bears will avoid using high value habitat near human disturbance, and McLellan and Shackelton (1988) found that even low volumes of traffic on tertiary roads led to displacement of bears. Displacement, habitat loss, and fragmentation are all indirect impacts of development and industry on grizzly bear populations. Direct mortality is attributed to increased hunting pressure (and vehicle collisions) resulting from increased access afforded through road development in the forestry, oil, and gas industries; poaching and illegal trade in body parts; and inadequate garbage management (B.C. MoELP, 1997; Hamilton, 1989). Hamilton (1989:16) states that "access can be viewed as the major impact that resource extraction industries have on wildlife populations".

The different factors affecting grizzly bear populations whether direct mortality resulting from increased human use and access or indirect impacts causing displacement or habitat loss are interactive (Knight and Cole, 1995). There is a cumulative effect of the combined impacts of these factors through time and across the landscape (Weaver *et al.,* 1985). Grizzly bears are known to follow regular travel routes, and any feeding habitats immediately adjacent to their well established trails will have increased value.

Warm aspect units, especially avalanche tracks and meadows, will have increased value in early spring. Habitats adjacent to areas of human disturbance will have decreased value.

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8.0 SPECIES – HABITAT MODEL FOR FISHER

Common Name:	**Fisher**
Scientific Name:	*Martes pennanti*
Species Code:	M-MAPE
B.C. Status:	Blue-listed (B.C. MoELP, 1996; B.C. CDC, 1997)
Identified Wildlife Status:	Yes (B.C. MoELP, 1997)
COSEWIC Status:	Not applicable

Fishers are managed as Class 2 fur-bearers as they are not present on most registered traplines in manageable numbers, and fishers are vulnerable to over-harvest (B.C. Ministry of Environment, 1991).

8.1 Introduction

The fisher is blue-listed because of suspected population declines and has been identified as a species of management concern. It is currently included as an Identified Wildlife Species in *Identified Wildlife Management Strategy* (1997) for the *Forest Practices Code of British Columbia.*

Fisher habitat ecology and diet including fisher-prey relationships are not well researched for northeastern British Columbia (B. Webster, L. Wilkinson, *pers. comm.*). Information presented in the species-habitat model has therefore been extrapolated from other regions, and relevant literature from B.C. has been included where it is available. There is currently an ongoing study in the northern interior (Mackenzie Forest District). Information from initial discussions with the biologists working on this fisher study in the Mackenzie has been incorporated into the species models, and it is hoped that research from this study will help to improve this model in future years. At this time, general habitat ratings for the fisher are predicted to have a low reliability as no model verification has been done and there is little or no documentation of the fisher habitat associations for this part of British Columbia.

8.2 Distribution

8.2.1 Provincial Range

Fishers are found at low densities throughout the boreal forests of British Columbia (Banci, 1989) where they reach the northern extent of their range in the province (Banci, 1989). However, fishers also occur within the Liard river basin of the southeastern Yukon where they are believed to be rare (Penner, 1981; Slough, 1985).

Fishers are generally well distributed across British Columbia, occurring in most ecoprovinces and biogeoclimatic zones with the exception of the coastal islands and the southern portions of the Southern Interior and Southern Interior Mountains Ecoprovinces. However, their detailed distribution is not known and could be quite patchy within this broader range. Further inventory is required to confirm suspected ranges (RIC, 1997f).

In many northern areas including the Williston Lake area, population numbers are thought to be traditionally low (D. Becker, *pers. comm*.). Within British Columbia, fisher are considered to be common-abundant yearlong in the moist, warm BWBS and in the forested variant of the SWB zone (SWBmk) (Stevens, 1995). Fishers are fairly evenly distributed throughout the Fort Nelson area with trappers reporting fairly consistent numbers of fishers caught (J. Hart, *pers. comm.*). The fisher population within the Liard river drainage to the north of the study area is considered to be low (Penner, 1981). Low numbers of fishers are present within the Dunedin study area (J. Hart, *pers. comm.*), and they occur in both the MUP and MUF ecosections represented within this area. Fisher occurrence within the ecoregions, ecosections, and biogeoclimatic zones of the study area is summarized in Table 52.

Table 52: Expected fisher Occurrence within the 6 ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	**TAIGA PLAINS**		**NORTHERN BOREAL MOUNTAINS**			
Ecoregions	**Muskwa Plateau**		**Northern Canadian Rocky Mountains**			
Ecosections	**MUP**		**MUF**			
BEC Variants	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**SWBmks**	**AT**
Species						
Fisher	•	•?	•	•	•?	x

Legend:
- • = occurs in the variant
- •? = probably occurs in the variant
- ? = unlikely to occur in the variant
- x = essentially absent

8.2.2 Elevational Range

Elevations within the study area range from approximately 250 m to 2105 m. Fishers are not commonly found in the AT zone or in the upper elevations (shrub variant) of the SWB zone due to lack of tree cover. Fishers are therefore unlikely to occur at elevations above 1400 m as this is the approximate BGC boundary of the SWBmk and SWBmks. Fishers prefer areas of higher canopy closure that are more often associated with lowland forest (Powell, 1982). Generally, fishers occur at the middle range of elevations and changes in elevation between seasons do not often occur (Banci, 1989).

8.3 Ecology and Habitat Requirements

Fishers occur primarily in forested landscapes and often prefer late succession forest over younger seral stages (Jones and Garton, 1994, in Weir and Harsted, 1997). Although there is relatively little known on fisher ecology and habitat use in North America, it appears that fishers in western coniferous forests may rely on the structures and ecological process associated with late successional stands to fulfill many of their life requirements (Ruggiero *et al.,* 1994). Fishers will avoid traveling through areas of deep, soft snow and will use forests with snow interception during periods of deep snow accumulations (Arthur *et al.,* 1989; Raine, 1983). The types of forests that provide snow interception are generally mature coniferous stands.

Fisher establish home ranges that are used all year. Home range sizes for fisher are 20 km^2 to 34 km^2 for adult males and 15 km^2 to 19 km^2 for females (Weir and Harested, 1997). Home ranges within the sexes do not overlap, but male and female ranges do overlap.

8.4 Habitat Use (Life Requisites and Seasons)

Fisher habitat use for the study area is broken down into two seasons – growing and winter. Life requisites that are rated for the fisher include living, feeding, reproducing, and combined security/thermal, as summarized in Table 53.

Table 53: Summary of Rated Life Requisites and Seasons for Fisher in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use
Living during the growing season - food Living during the growing season - security/thermal	LI_G_FD LI_G_ST	May-September
Living during the winter season - food Living during the winter season - security/thermal	LI_W_FD LI_W_ST	October-April
Reproducing by birthing - security	RB_SH	March-May

Rated life requisites are described in detail below.

8.4.1 Living

In general, fishers prefer a diversity of forest types with a high degree of interspersion (Arthur *et al.,* 1989; Banci, 1989). Fishers use multi-aged stands interspersed with openings, wetlands, edges, or ecotones (Banci, 1989; Powell and Zielinski, 1994), and riparian forests are important for fishers (Buck *et al.,* 1994; Powell and Zeilinski, 1994) as they select for old-growth habitat elements in riparian stands (Weir, 1995). In the MacKenzie area, high fisher use has also been found in areas with cottonwoods and kettle lake systems (D. Becker, *pers. comm.*).

A high degree of diversity in tree heights, shapes, light gaps, associated understory vegetation, coarse woody debris, snags, and many layers of cover are preferred in forest habitat types (Buskirk and Powell, 1994, in Powell and Zielinski, 1994; Weir, 1995). This complexity in forest structure and the associated prey may be key features in habitat preferences of fishers (Buskirk and Powell, 1994, in Powell and Zielinski, 1994).

8.4.2 Feeding

Fishers are generalist feeders and have diverse diets dominated by small to medium sized mammals, birds, and carrion. The staple food groups of the fisher are snowshoe hare, porcupine, deer, moose (obtained primarily as carrion), squirrels, small mammals, and birds (Banci 1989, Weir 1995). The main prey identified by Weir (1995) in Central British Columbia included snowshoe hares, red squirrels, and small mammals including southern red-backed voles. Fishers in B.C. tend to use porcupine less than is documented in other study areas, and they tend to use moose carrion rather than deer carrion (Weir, 1995).

Throughout most of the fisher's range, snowshoe hares are probably the primary food source (Kuehn, 1989). Studies in Manitoba found snowshoe hares to constitute 70% (Raine, 1987) and 84.3% (Raine, 1986) of fisher diets. Snowshoe hares composed 31.4% of fisher diets in South-Central B.C. and were recorded as the most frequently used species of prey (Weir, 1995). Although literature indicates that fisher numbers may be largely reflective of hare abundance in many areas (RIC, 1997f), Weir (1995) suggests that fisher diets in B.C. may not be as dependent on hare as those in more eastern regions. This is supported by findings of Kuehn (1989). Fishers will switch prey in response to availability (Banci, 1989), and they can thus compensate for decreases in populations of their primary prey by switching to more available prey items (Kuehn, 1989; Weir, 1995).

Fishers do not exhibit seasonal diet differences, but there is an increased use of plant material especially fruits and nuts during summer (Powell and Zielinski, 1994).

8.4.3 Security Habitat and Thermal Habitat (Resting Sites)

Fishers avoid non-forested areas (Jones and Garton, 1994; Powell and Zielinski, 1994; Thomasma *et al.,* 1994; Weir, 1995) and mixed selectively logged stands (Weir, 1995). Kelsall *et al.* (1977) found fishers to be virtually absent from recently burned or logged stands but to utilize second-growth stands more than marten will. Fishers are generally believed to require closed canopy habitats, although apparently at least some of that canopy may be deciduous (RIC, 1997f). They selected sites with >20% canopy closure in Central B.C. (Weir, 1995) and >50% in a habitat study in Michigan (Thomasma *et al.,* 1994), although 21% to 41% of the canopy may be deciduous (Weir, 1995; RIC, 1997f). Fishers select for trees >27cm dbh in Michigan (Thomasma *et al.,* 1994).

Resting sites can be quite diverse including snow dens, hollow logs, holes in the ground, tree cavities, snags, and downed logs (Banci, 1989). Tree species used for resting in the Williams Lake area included aspen, cottonwoods, Douglas-fir, and spruce (Weir, 1995). Keisker (1996) suggests that CWD in decay classes 1, 2, and 3 are the most important for resting and denning sites. In the winter, fishers select for spruce stands with aspen components and use CWD and slash piles for thermal protection when temperatures are low (Weir, 1995).

8.4.4 Reproduction

There is very little information on the reproductive habits of fishers in western North America. Generally, fishers may give birth as early as January but more commonly in March to April having 1 to 4 (average of 2 to 3) kits (Banci, 1989; Powell, 1982). Breeding takes place soon after parturition with the breeding season from late February to mid April (Banci, 1989). Female fishers become sexually mature and begin breeding at the age of one and have their first litter when they are two (Powell and Zielinski, 1994). Kits become independent at four to five months of age (Powell and Zielinski, 1994).

Most information on natal dens (where parturition occurs) and maternal dens (different dens where young are raised) comes from eastern North America. Fisher kits are generally moved from natal to maternal dens when they are about 8 to 10 weeks old (Powell and Zielinski, 1994). In south-central B.C., Weir (1995) found females moved their kits to different maternal den trees 4 to 6 weeks following parturition. Female fishers will use 1 to 3 dens per litter and will move dens if disturbed (Paragi, 1990, in Powell and Zielinski, 1994). Den requirements include thermal protection for kits and security from predators (Banci, 1989). In general, tree cavities are used almost exclusively for natal and maternal dens, and large, dead or living trees are needed to provide suitable den sites (Powell and Zielinski, 1994). Most natal dens found have been in hardwoods – most commonly aspens (Powell and Zielinkski, 1994). In south-central B.C., Weir (1995) found fishers whelped exclusively in large cottonwood trees (mean diameter 103 cm) with heart rot and branch hole. These trees were relatively rare in stands and were frequently found in riparian and riparian-associated habitats (Weir, 1995). Dens were located an average of 25.9 m above the ground (Weir, 1995). Weir (*pers. comm.*) suggested that large diameter cottonwoods could be significant, even possibly limiting, for natal denning and whelping in the north-central interior (Weir, 1995). Structural stage 6 and 7 forests are probably the only habitats that will consistently provide large trees with suitable den attributes.

8.4.5 Seasons of Use

Table 54 summarizes the rated life requisites for fisher for each month of the year.

Table 54: Monthly Rated Life Requisites for Fisher in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	LI-ST, FD
February	W	LI-ST, FD
March	W	LI-ST, FD; RB-SH
April	W	LI-ST, FD; RB-SH
May	G	LI-ST, FD; RB-SH
June	G	LI-ST, FD
July	G	LI-ST, FD
August	G	LI-ST, FD
September	G	LI-ST, FD
October	W	LI-ST, FD
November	W	LI-ST, FD
December	W	LI-ST, FD

Legend
W=Winter G=Growing LI=Living FD=Food ST=Security/Thermal RB=Reproducing (birthing)
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

8.5 Habitat Use and Ecosystem Attributes

Table 55 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 55: Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for Fisher

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	Volume of coarse woody debris (>50 m^3/ha), mixed wood, coniferous, and deciduous forests (structural stages 5, 6, 7) with abundant shrub/ground cover
Living Habitat (Security/Thermal)	% cover of shrubs and trees (>20% canopy closure); coarse woody debris; other structural elements Resting sites - Large diameter (>20 cm) coarse woody debris, rust broom, cavities in large trees
Reproduction	Older stage (6 or 7) forests, large diameter cottonwood trees, or other tree spp., e.g. aspen

8.6 Development of the Habitat Ratings

8.6.1 Rating Scheme
A 4-class rating scheme of high (H), moderate (M), low (L) and nil (N) is employed (as suggested for fisher by RIC, 1998) and requires an intermediate knowledge of habitat use The used ratings scheme is defined in Table 56.

Table 56: Habitat capability and suitability 4-class rating scheme (from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	H
75% - 26%	Moderate	M
25% - 1%	Low	L
0%	Nil	N

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for the fisher, as previously outlined in Table 53.

8.6.2 Provincial Benchmark
A provincial benchmark has not yet been established for fisher.

8.6.3 Ratings Assumptions
Habitat ratings for the fisher are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the fisher's seasonal requirements for reproducing, feeding, and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 55) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- Units with abundant CWD and snags have more value year round as these structures provide resting sites and thermal and security habitat. Stands with no coarse woody debris are avoided, and, in winter, stands with >50 m3/ha of CWD >20 cm in diameter, which is not resting on the ground, are preferred (Weir 1995).
- Resting and denning is limited to structures such as large trees, CWD, and snags found in late-successional forests (Powell and Zielinski, 1994). Stands with <20% canopy closure receive low security/thermal ratings as fishers selected for sites with >20% canopy closure in Central B.C. (Weir, 1995). Structurally complex habitats with aabundant shrub layers and CWD will enhance security and thermal values for fishers and are given higher ratings. In both the winter and growing seasons, structural stage 6 and 7 are considered to provide optimal security/thermal habitat. Stages 4 and 5 are generally less structurally complex and will have lower security/thermal values, and stages 1 to 4 have poor values. Some stage 3 units with dense overhead shrub cover can provide moderate security/thermal values during the growing season.
- In the winter, excessive snow depth may restrict fisher movements (Raine, 1983). During times of little snow or when heavy crust is present, fishers are able to travel extensively and may utilize most site series for hunting. However, during severe winters, mature, closed canopy, coniferous-dominated stands are probably important habitat for fishers providing thermal cover and relatively shallow snow depths that will not hinder fisher

movement. Structural stages 1 to 4 are rated as having minimal security habitat value in a winter of average snowfall.

- Fishers forage in habitat that provides food and cover for their prey, primarily snowshoe hares, squirrels, and small mammals (Weir, 1995). Low conifer branches, coarse woody debris, abundant low and high shrub cover, rocks, and small trees that offer the dense physical structure required by snowshoe hare (Livaitis *et al.,* 1985) are selected by fishers (Buskirk and Powell, 1994; Powell, 1982; Weir, 1995). Small mammal populations are greater in areas with good security and thermal cover. These are generally structurally complex, productive sites with dense low and high shrub layers and large volumes of CWD. Riparian and riparian associated units provide many of these attributes and receive high foraging ratings.
- As stated above, forest stands with greater structural diversity have higher feeding values due to presence of more prey and more opportunities for hunting. Winter feeding values closely reflect security/thermal values with structural stage 6 and 7 forests providing the optimal foraging attributes, 4 and 5 having moderate values, and stages 1 to 4 having low feeding values. In an average winter, prey is assumed to be present yet not accessible to fishers in these younger structural stages (1 to 4) due to restrictive snow depths.
- During the growing season, most forested units within the study area probably have some foraging values as fisher prey can be found in a variety of seral stages and forest types. Structural stage 6 and 7 habitats provide optimal foraging attributes, stage 5 and 4 generally provide moderate values. Stage 3, 3a, and 3b units may receive some low use for hunting in summer when some overhead cover from brush and saplings is provided and mature stands are adjacent. Fishers avoid non-forested areas (Jones and Garton, 1994; Powell and Zielinski, 1994; Thomasma *et al.,* 1994; Weir, 1995); therefore, structural stages 1 and 2 are given poor foraging and security/thermal values in both the winter and growing seasons.
- Within the BWBSmw2, the AM/01 and 01$ and SH/05 and 05$ forests probably have moderate-high value during spring through fall as they are generally quite diverse and have many-layered canopies. The BL/04 site series has limited structural diversity and presumably has low foraging value due to subsequent low prey diversity. Wetter ecosystem units (e.g., BS/08 and BW/09) and drier units (e.g., LL/02) may have low prey abundance due to the wetness/dryness of sites and may therefore have low foraging values. Edges and ecotones between units have high value as they are usually very diverse and should have good abundance of several different prey items. Since fisher are generalist hunters and use prey in relation to availability often taking advantage of cyclic prey populations, it is difficult to assess habitat in terms of prey availability.
- Structural stages 6 and 7 are probably the only stages that will consistently provide suitable trees for natal dens within the study area when they have a mature deciduous component. Fishers use large balsam poplar for birthing in south-central B.C. (Weir, 1995). Units that supply large diameter balsam poplar and aspen are given the highest reproducing ratings. Riparian units often have large trees and are rated as high value.
- Fishers are not commonly found in the AT zone or in the SWBmks due to a lack of security/thermal habitat at these higher elevations. All ecosystem units in these zones are given nil values for security/thermal, food, and reproducing for all seasons with the exception of a few shrubby units in the SWBmks that may have some limited food value during the growing season.

8.6.4 Rating Adjustment Considerations

Landscape fragmentation will reduce the value of habitats. Fishers generally avoid non-forested or open areas with little overhead cover when travelling (Powell and Zielinski, 1994; Weir, 1995); and highly fragmented areas will have little connectivity between mature habitats, making travelling between units difficult.

In the aspen parklands of Alberta, fishers were found to prefer continuous forests and were rarely found in stands less than 100 ha in size (Badry *et al.,* 1997). Therefore, stand size may also be an important factor in determining habitat value with small patches of forest having reduced value.

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9.0 SPECIES – HABITAT MODEL FOR MARTEN

Common Name:	**Marten**
Scientific Name:	*Martes americana*
Species Code:	M-MAAM
B.C. Status:	Yellow-listed
Identified Wildlife Status:	None
COSEWIC Status:	Not applicable for western populations

The marten is managed as a Class 1 species as it is present on individual traplines in manageable numbers (B.C. Ministry of Environment, 1991).

9.1 Introduction

Marten habitat ecology and diet including marten-prey relationships are not well researched for northeastern British Columbia. There have been no specific marten habitat studies or inventories within the Dunedin study area (B. Webster, L. Wilkinson, *pers. comms.*). Information presented in the species-habitat model has therefore been largely extrapolated from other regions, and relevant literature from B.C., the Northwest Territories, and the lower Yukon Territory has been included where it is available. Most studies on marten ecology, habitat requirements, and food preferences were undertaken in the United States and Eastern Canada. From this literature, some aspects of marten ecology can be extrapolated; although, marten habitat use will vary regionally in accordance with ecological variation, habitat quality, prey availability, and prey abundance (Thompson and Colgan, 1990). Recent research has been completed in interior British Columbia (Lofroth, 1993; Lofroth and Steventon, 1990) and has been incorporated into the species-habitat model. At this time, general habitat ratings for the marten are predicted to have a low to moderate reliability as no model verification has been done.

9.2 Distribution

9.2.1 Provincial Range

Marten occur throughout British Columbia and are usually confined to the forested biotypes (Stordeur, 1986). According to Hagmeier (1956), marten occur throughout the following biotic areas of British Columbia: Caribou Parklands, Columbia Forests, Subalpine Forest, Boreal Forest, Peace River Parklands, Coast Forest, Queen Charlotte Islands, and Vancouver Island.

Marten are fairly evenly distributed throughout the Fort Nelson area with trappers reporting fairly consistent numbers of marten caught (J. Hart, *pers. comm.*). Within the Dunedin study area, moderate to high numbers of marten are present (J. Hart, *pers. comm.*). Marten occurrence within the ecoregions, ecosections, and biogeoclimatic zones of the study area is summarized in Table 57.

Table 57: Expected Marten Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	**TAIGA PLAINS**		**NORTHERN BOREAL MOUNTAINS**			
Ecoregions	**Muskwa Plateau**		**Northern Canadian Rocky Mountains**			
Ecosections	**MUP**		**MUF**			
BEC Variants	**BWBSmw2**	**BWBSwk**	**BWBSmw2**	**SWBmk**	**SWBmks**	**AT**
Species						
Marten	•	•	•	•	?	x

Legend:
- = occurs in the variant

•? = probably occurs in the variant
? = unlikely to occur in the variant
x = essentially absent

Marten are generally separated into interior and coastal forms (Lofroth and Steventon, 1990). This species account is limited to interior forests as coastal marten may have different requirements (Nagorsen *et al.,* 1989).

9.2.2 Elevational Range

Elevations within the study area range from approximately 250 m to 2,105 m. Marten will not generally be found in the AT zone or in the upper elevations (shrub variant) of the SWB zone due to lack of security habitat. Marten are unlikely to occur at elevations above 1,400 m as this is the approximate BGC boundary of the SWBmk and SWBmks.

9.3 Ecology and Habitat Requirements

Across most of North America, marten prefer coniferous or mixed wood forest and tend to be associated with late seral stages with complex structures and uneven-aged stands (Soutiere, 1979; Snyder and Bissonette, 1987; Spencer *et al.,* 1983; Stevenson and Major, 1982; Weckworth and Hawley, 1962). However, they will tolerate a variety of forest habitats if specific habitat requirements are met (Strickland and Douglas, 1987).

A winter survey by Penner (1981) in the Liard River Valley of B.C. (to the immediate north of the study area) found that marten preferred spruce forest and burned areas with tall, deciduous shrub and pole-sized aspen. They generally avoided black spruce wetland forest, burn with lodgepole pine regeneration, floodplain deciduous and coniferous forests, and habitats with no cover. Spruce-fir sites are generally preferred by marten over lodgepole pine sites (Buskirk *et al.,* 1989; Corn and Raphael, 1992). In the Liard River Valley, Yukon Territory, marten were found to show a distinct preference for white spruce dominated cover types as did the red squirrel and snowshoe hare (Slough, 1988). The alluvial white spruce was found to be the best marten habitat, and marten were found to be moderately abundant in the widespread upland pine forests (Slough, 1988).

Marten home range sizes vary significantly among geographic areas and between sexes (Buskirk and McDonald, 1989; Soutiere, 1979; Weckworth and Hawley, 1962) and reflect habitat quality (Soutiere, 1979). Females have smaller home ranges than males (Baker, 1992), which may reflect sexual dimorphism (males are heavier than females). Home range sizes were reported as 5.9 km^2 and 2.1 km^2 for males and females respectively in the Yukon (Archibald and Jessup, 1984, cited in Thompson and Colgan, 1987), 6.8 km^2 and 3.7 km^2 for males and females in Alaska (Buskirk, 1983, cited in Thompson and Colgan, 1987) and have been predicted to be 1.0 km^2 to 5.6 km^2 in the Quesnel area (Keystone Wildlife Research, 1995).

9.4 Habitat Use (Life Requisites and Seasons)

Marten habitat use for the study area is broken down into two seasons – growing and winter. Life requisites that are rated for marten include living, feeding, reproducing, and combined security/thermal, as summarized in Table 58.

Table 58: Summary of Rated Life Requisites and Seasons for Marten in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use
Living during the growing season - food Living during the growing season - security/thermal	LI_G_FD LI_G_ST	May-September
Living during the winter season - food Living during the winter season - security/thermal	LI_W_FD LI_W_ST	October-April
Reproducing by birthing - security	RB_SH	March-May

Rated life requisites are described in detail below.

9.4.1 Living

Life requisites for marten include water, food, foraging sites, resting and maternal den sites, security cover, and a good interspersion of habitat types providing these requisites (Lofroth and Banci, 1991). Numerous studies have documented that marten inhabit late successional forest communities and are abundant in association with mature coniferous species (Becker, 1992).

Marten have been found to decline with removal of forested habitat, increased human access, and unrestricted trapping (Clarke *et al.,* 1987 cited in Becker, 1992). Hargis and Bissonette (1997) determined that forested areas with more than 25% removal were not used by marten, and there were no increases in marten densities with increases in prey abundance concurrent to low levels of fragmentation. Steventon and Major (1982) found that marten avoided clearcuts in the winter and used them less than expected (in proportion to availability) in the summer, foraging for berries when available. Many ecology studies have found that marten do not significantly use clearcuts for 15 to 40 years post-harvesting (Soutiere, 1979; Snyder and Bissonette, 1987; Slough, 1988; Thompson, 1994). Thompson (1994) found that in Ontario, marten densities in uncut forests were 90% higher than those of marten in harvested forests.

9.4.2 Feeding

Marten are opportunistic foragers and consume a variety of prey, although most studies suggest that they are arvicolid (microtine) specialists (Buskirk and MacDonald, 1984; Koehler and Hornocker, 1977; Quick, 1955; Weckwerth and Hawley, 1962). Many studies have found marten use voles more than any other single food item (Buskirk and MacDonald, 1984; Cowan and Mackay, 1950; Koehler and Hornocker, 1977; Soutiere, 1979; Quick, 1955; Weckworth and Hawley, 1962), although there is much geographical variation in diets. Most studies on marten diet do not extend to the summer. Marten have a diverse summer diet of mammals, eggs, birds, fish, insects, and carrion. Berries are foraged when available especially *Vaccinium* spp. and *Rubus* spp. (Buskirk and Ruggiero, 1994), wild sarsaparilla, and saskatoon (Thompson and Colgan, 1990). Open meadows and burns may be used in the summer if adequate cover is available for accessing berries and insects (Koehler and Hornocker, 1977).

Winter Season

Quick (1955) identified the winter diet of marten in Northern B.C. as including (in order of importance) red backed vole, deer mouse, red squirrel, snowshoe hare, bird (spp. unknown), grouse, shrew, and porcupine. Squirrels and/or hares become more important in late winter and early spring (Buskirk and Ruggiero, 1994; Buskirk and MacDonald, 1984; Northern Biomes Ltd., 1983). Douglass *et al.* (1983) found voles to be the major winter food source of marten in the boreal forest of the Northwest Territories. A study by Koehler *et al.* (1990) on marten use of different successional stages in the winter confirmed previous findings that marten did not forage in younger successional stages but selected older-aged stands with higher occurrences of voles. Red-backed voles were found to be one of the most important components of marten winter diets in the Williston Reservoir area (D. Becker, *pers. comm.*).

A crucial component of marten winter feeding habitat is availability of access points to subnivean (under snow) spaces where the majority of hunting occurs (Lofroth and Steventon, 1990; Sherburne and Bissonette, 1994). Corn and Raphael (1992) found that marten used existing openings to gain access created by coarse woody debris at low snow depths and by lower branches of live trees in deeper snow. In the south-central Yukon Territory, marten were also found to use primarily passive means to gain access to the subnivean using tree trunks, deadfall, and saplings (Northern Biomes Ltd., 1983). Decayed stumps and trees of large diameter may also provide access (Steventon and Major, 1982; Hargis and McCollough, 1984).

In the SBS biogeoclimatic zone, the best foraging habitats contain >100m^3/ha of coarse woody debris at least 20 cm in diameter, 5 m^2/ha basal area of snags at least 20 cm in diameter, and at least 30% canopy closure (Lofroth and Banci, 1991).

9.4.3 Security Habitat and Thermal Habitat (Resting Sites)

Marten will avoid areas with little or no canopy cover and generally prefer a coniferous canopy cover of 30% to 80% (Lofroth and Banci, 1991; Lofroth and Steventon, 1990; Spencer *et al.,* 1983). However, they will avoid stands that are so dense as to suppress herbaceous cover (Spencer *et al.,* 1983). Marten seldom venture more than 100 m into openings (Hargis and McCollough, 1984; Spencer *et al.,* 1983; Lofroth and Steventon, 1990). In the Liard Valley, Yukon Territory, marten used the edges of clearcuts but seldom ventured more than 10 m from cover (Slough, 1988). Overhead cover (especially near the ground) is needed as security cover to provide protection from both avian and terrestrial predators (Buskirk and Ruggiero, 1994; Thompson, 1994). Marten also require trees of pole size or bigger to climb to escape predation. Resting sites also provide protection from predators.

Resting sites are often associated with large woody debris, cavities in decayed logs, squirrel middens, snags, stumps, and logs (Buskirk, 1984; Buskirk *et al.,* 1989; Spencer, 1987). Sites used during periods of severe winter temperatures were found to be selected based on their thermal properties (Buskirk *et al.,* 1989). During winter in the central Rocky Mountains, Buskirk *et al.* (1989) found marten primarily used subnivean resting sites where coarse woody debris was available to provide thermal cover. Above snow sites were used in warmer weather. A close association between marten and red squirrels was found in south-central Alaska where marten primarily used active middens as resting sites (Buskirk, 1984). Spencer (1987) observed a similar relationship between marten and decayed log cavities used as middens by Douglas' squirrels. Subnivean sites were used exclusively under continuous snow conditions.

Keisker (1996) suggests that although marten use wildlife trees in Classes 2 to 7, they will select trees in the wildlife tree classes 4,5,7, and occasionally 8 for resting and denning.

They also show preference for resting sites in large branches available in black cottonwood trees and to a lesser extent lodgepole pine and aspen. Non-winter resting sites include witches broom in hybrid white spruce and lodgepole pine.

9.4.4 Reproduction

Breeding takes place from late June to early August with the peak of activity in July (Stordeur, 1986). During March and April, marten give birth in dens to 1 to 6 (average of 3) kits (Stordeur, 1986). The young emerge from the dens at about 50 days of age, although they may be moved among dens previous to this (Buskirk and Ruggiero, 1994).

Marten use two types of dens: natal dens (where parturition occurs) and maternal dens (different dens where young are raised) (Buskirk and Ruggiero, 1994). Females will generally change den sites when kits become mobile (Lofroth and Bianci, 1991). Little information exists on requirements for maternal den sites, although it is suggested that sheltered sites in snags and woody debris may make appropriate maternal denning sites (Lofroth and Banci, 1991). Natal and maternal dens are commonly found in trees, logs, and snags associated with large structures that are characteristic of late-successional forest (Buskirk and Ruggiero, 1994). Buskirk and Ruggiero (1994) report that natal dens are found in habitats with more developed old-growth characteristics compared to those of maternal den sites and that structurally complex forested habitats will be used more frequently for natal denning. During the whelping period, above ground dens may be required to protect kits from wet spring ground conditions (Wynne and Sherburne, 1984). Structural stage 6 and 7 forests are probably the only habitats that will consistently provide large trees and structures with suitable natal and maternal den attributes.

9.4.5 Seasons of Use

Table 59 summarizes the rated life requisites for marten for each month of the year.

Table 59: Monthly Rated Life Requisites for Marten in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	LI-ST, FD
February	W	LI-ST, FD
March	W	LI-ST, FD; RB-SH
April	W	LI-ST, FD; RB-SH
May	G	LI-ST, FD; RB-SH
June	G	LI-ST, FD
July	G	LI-ST, FD
August	G	LI-ST, FD
September	G	LI-ST, FD
October	W	LI-ST, FD
November	W	LI-ST, FD
December	W	LI-ST, FD

Legend
W=Winter G=Growing LI=Living FD=Food ST=Security/Thermal RB=Reproducing (birthing)
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

9.5 Habitat Use and Ecosystem Attributes

Table 60 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 60: Terrestrial Ecosystem Mapping (TEM) Relationships for Each Life Requisite for Marten

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	Volume of coarse woody debris; mixedwood, coniferous forests, structural stages 5, 6, 7; % cover shrubs and trees
Living Habitat (Security/Thermal)	% cover of shrubs and trees (>30% canopy closure); coarse woody debris (>20 cm diameter and 100m^3/ha), other structural elements Resting sites - Large diameter (>20 cm) coarse woody debris; squirrel middens, cavities in large trees, size and quality (class)
Reproduction	Large diameter coniferous and deciduous trees, older stage (6-7) coniferous and mixed forests, snags

9.6 Development of the Habitat Ratings

9.6.1 Rating Scheme

A 4-class rating scheme of high (H), moderate (M), low (L), and nil (N) is employed (as suggested for marten by RIC, 1998) and requires an intermediate knowledge of habitat use. The used ratings scheme is defined in Table 61.

Table 61: Habitat Capability and Suitability 4-Class Rating Scheme (from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	H
75% – 26%	Moderate	M
25% – 1%	Low	L
0%	Nil	N

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for marten, as previously outlined in Table 58.

9.6.2 Provincial Benchmark

A provincial benchmark has not yet been established for marten. Stordeur (1986) established a high density rating for marten for the BWBS biogeoclimatic zone, a low density rating for the SWB zone, and marten were considered absent in the AT zone. Based on this, habitats within the BWBS of the Dunedin study area were rated up to high value.

9.6.3 Ratings Assumptions

Habitat ratings for marten are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the marten's seasonal requirements for reproducing, feeding, and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 60) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- Forest cover composition, coarse woody debris (CWD) size and abundance, and relative prey abundance are assumed to directly affect habitat values for marten.
- The present model assumes marten are using a winter subnivean prey source, and alternate food sources (hares, squirrels, and carrion) have not been taken into account.
- Later seral stages (stages 6 and 7) have higher habitat value year round as they have greater amounts of large size CWD, stumps, snags, and larger trees. These habitat characteristics increase the number of potential available resting den sites, thermal cover, and access to subnivean hunting in winter. Structural stages 6 and 7 are also probably the only stages that will consistently provide suitable trees and structures for natal and maternal dens within the study area. Units which supply large diameter coniferous and deciduous trees are given the highest reproducing ratings.
- Marten require at least pole size or bigger trees to escape predation, and smaller trees will not provide adequate security cover. In both the growing and winter seasons, structural stages 6 and 7 are presumed to provide optimal security/thermal habitat. Stages 4 and 5 will have lower security/thermal values, and stages 3, 3a, and 3b will generally have poor values. Marten generally avoid habitats that lack overhead cover (Hargis and McCollough, 1984; Spencer *et al.,* 1983; Lofroth and Steventon, 1990). Structural stages 1 and 2 are therefore given ratings of nil for security/thermal habitat for both the growing and winter seasons. Some stage 3, 3a, 3b units with dense overhead shrub cover can provide moderate security/thermal values during the growing season. Structural stages 3 and 4 probably have minimal winter value due to limited subnivean access points and lack of den sites and thermal cover and are therefore given low ratings.
- As marten will avoid open areas and generally prefer a coniferous canopy cover of 30% to 80% (Lofroth and Banci, 1991; Lofroth and Steventon, 1990; Spencer *et al.,* 1983) stands with <30% canopy closure are given low security habitat ratings year round. Coniferous trees provide more canopy closure than deciduous trees during winter and thereby provide better thermal protection and security cover from aerial predators. Habitats with low levels of coniferous composition receive low security values.
- Abundance of prey items increases the value of marten habitat and areas with suitable habitat for prey (assumed to be mainly small mammals) have high food values for marten. Small mammal populations are greater in areas with good security and thermal cover. These are generally productive sites with abundant low shrub and herb layer and abundant CWD. Coarse woody debris is also required to provide access points to subnivean hunting for marten. Abundant shrub layers will also enhance security and thermal values for marten. Units that produce good berry crops will also have higher feeding values in the growing season as marten will often forage on berries in the late summer and fall.
- Submesic to subhygric moisture regimes with abundant shrub cover provide the most suitable habitat for small mammals (Lofroth and Banci, 1991). Dryer sites are not productive enough to provide good habitat for small mammals; and wetter sites, although productive, may have surface and sub-surface water present reducing availability of subterranean habitats (Lofroth and Banci, 1991).
- In a winter of average snowfall, prey is assumed to be present yet not accessible to marten in younger structural stages (1 to 4) due to an absence of access points and

CWD. These structural stages are therefore given low food values. When snow cover is low, more open areas with shrub cover may receive some hunting use due to the greater abundance of prey in these units. However, security/thermal habitat is usually limiting in these areas. In the growing season, food items in all structural stages were assumed accessible to marten, and food values are reflective of presence of food; nevertheless, marten are unlikely to forage extensively in structural stages 1 to 3 due to a lack of security/thermal habitat. If sufficient shrub cover exists, marten may forage farther into stage 3, 3a, and 3b shrubby burns and clearcuts. Stage 1 ecosystems do not generally support marten prey and are therefore given nil or low food ratings. Stage 2 units have abundant marten prey yet will have poor foraging value due to the openness of these habitats. In both the growing and winter seasons, structural stages 6 and 7 presumably provide optimal feeding habitat and stage 4 and 5 have moderate values.

- Marten are not commonly found in the AT zone or in the SWBmks due to a lack of security/thermal habitat at these higher elevations. All ecosystem units in these zones are given nil values for security/thermal, food, and reproducing for all seasons, with the exception of a few shrubby units in the SWBmks that may have some limited food value during the growing season.

9.6.4 Rating Adjustment Considerations

Marten generally avoid habitats that lack overhead cover and seldom venture more than 100 m into openings (Hargis and McCollough, 1984; Spencer *et al.,* 1983; Lofroth and Steventon, 1990). Marten will presumably avoid travelling across large open areas. Landscape fragmentation will thus reduce the value of habitats, as highly fragmented areas will have little connectivity between mature habitats, making travelling between units difficult.

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10.0 SPECIES – HABITAT MODEL FOR ROCKY MOUNTAIN ELK

Common Name:	**Rocky Mountain Elk**
Scientific Name:	*Cervus elaphus nelsoni*
Species Code:	M-CEEL
B.C. Status:	Yellow-listed
Identified Wildlife Status:	None
COSEWIC Status:	Not applicable

10.1 Introduction

The information presented in this species-habitat model has been largely extrapolated from other regions as there is little documentation of Rocky Mountain elk habitat associations for this part of British Columbia. There have been no specific elk habitat studies, inventories, or surveys completed within the Dunedin study area (B. Webster, *pers. comm.*). Regional information and relevant literature from B.C. and western North America has been incorporated into this species-habitat model where applicable. At this time, general habitat ratings for the Rocky Mountain elk are predicted to have a low reliability as no model verification has been done and elk habitat ecology and diet are not well researched in this region of northeastern British Columbia. Before more reliable ratings of habitat value can be developed, data is required on the seasonal food habits and habitat selection of Rocky Mountain elk in this region.

10.2 Distribution

10.2.1 Provincial Range

Two subspecies of elk occur in British Columbia (Cannings and Harcombe, 1990; RIC, 1997e). Roosevelt elk (*Cervus elaphus roosevelti*) are provincially blue-listed with populations restricted to Vancouver Island and the Sunshine Coast. Rocky Mountain elk are found in a patchy distribution over southeastern and northeastern British Columbia with smaller populations occurring in the Okanagan and near Lytton (RIC, 1997e). The greatest elk densities are found in the East Kootenay and Muskwa/Kechika areas (RIC, 1997d).

10.2.2 Distribution in the Study Area

Populations of elk along the Liard river are at the northern limit of elk distribution in western Canada, are scattered, and are found in low numbers (Goulet and Haddow, 1985). Most elk present within this region are found in the foothills (B. Webster, *pers. comm.*). A small herd of elk (estimated at 150 animals in 1982) is known to inhabit the headwaters of the Toad River and to range north to the Liard River. B. Webster (*pers. comm.*) confirms the presence of a few elk in the headwaters of the Dunedin and Snake rivers, which are thought to winter in the foothills at the head of the Dunedin and the Snake. Distribution of elk herds in the area in 1988 can be found in maps produced by the Fish, Wildlife and Habitat Protection Department (1994). Elk distribution seems to have spread out in recent years with elk expanding into logged blocks along many of the major rivers (J. Hart, *pers. comm.*). Elk have been seen occasionally along the Liard river from the Toad river to Nelson Forks and east along the Fort Nelson river (J. Hart, *pers. comm.*). M. Labine (*pers. comm.*) reported that elk have been seen as far north as Fort Liard with a few seen in winter in cutblocks along the Liard river.

Elk are found within all of the ecoregions, ecosections and biogeoclimatic zones found within the Dunedin study area, as summarized in Table 62.

Table 62: Expected Rocky Mountain Elk Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	**TAIGA PLAINS**		**NORTHERN BOREAL MOUNTAINS**			
Ecoregions	**Muskwa Plateau**		**Northern Canadian Rocky Mountains**			
Ecosections	**MUP**		**MUF**			
BEC Variants	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**SWBmks**	**AT**
Species						
Rocky Mountain Elk	•	•	•	•	•	•

Legend:
- = occurs in the variant

10.2.3 Elevational Range

Elevations within the study area range from approximately 250 m to 2,105 m. Rocky Mountain elk may be found from the BWBS zone up to the AT zone within the study area.

10.3 Ecology and Habitat Requirements

Elk may be found in coniferous forests of all ages, as well as in deciduous stands and non-forested habitats such as wetlands, vegetated slides, and rock outcrops (Nyberg and Janz, 1990). Elk prefer wet areas such as wetlands, meadows, estuaries, seepage sites, and riparian areas adjacent to streams and in alluvial floodplains of major river valleys. The moist, rich soils that typically occur in these areas provide abundant sources of preferred forage species. Elk are generally considered an ecotone species, preferring the transition zones between habitats (Skovlin, 1982). Levels of elk use have been found to decrease with increased distance from the interface of forest and nonforest communities (Skovlin, 1982).

Elk will generally winter on lower slopes and in the valleys where less snow accumulates (RIC, 1997d). In the Liard River Valley of B.C. (to the north of the study area), Goulet and Haddow found that riparian and floodplain habitats on major rivers, young burns, and grassy slopes provide suitable winter range for elk (Goulet and Haddow, 1985). In severe winters, mature coniferous forests may be critical for cover and snow interception. South-facing slopes are particularly important winter habitat. In a study of collared elk in the Fort Nelson area, most elk summering in logged blocks along the Muskwa river were migrating back to the Tuchodi Foothills in the fall, wintering in the alpine on south-facing bare hillsides, then returning to the Muskwa River area in the spring. A small number of animals were non-migratory, remaining in the logged blocks for the winter (J. Hart, *pers. comm.*).

10.4 Habitat Use (Life Requisites and Seasons)

Rocky Mountain elk habitat use for the study area is broken down into two seasons – growing and winter. Life requisites that are rated for elk include living, feeding, and security, as summarized in Table 63.

Table 63: Summary of Rated Life Requisites and Seasons for Rocky Mountain Elk in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use
Living during the growing season - food Living during the growing season - security	LI_G_FD LI_G_SH	May-September
Living during the winter season - food Living during the winter season - security	LI_W_FD LI_W_SH	October-April

Habitats used for reproduction (birthing) and rutting have not been rated as there is insufficient information available to distinguish these habitats. Elk are thought to calve in May within the Fort Nelson area, and the rut generally occurs in the second to third week of September along the Muskwa-Tuchodi area (J. Hart, *pers. comm.*).

Rated life requisites are described in detail below.

10.4.1 Living

Elk are generally migratory, usually frequenting alpine meadows in the summer and retreating down to river valleys in the fall. Some populations of elk are also nonmigratory, exhibiting only local shifts in habitat use (Peek, 1982). Ideal landforms range from floodplain areas with adjacent river breaks to steep avalanche tracks with >100% slope (Luttmerding *et al.,* 1990).

10.4.2 Feeding

Growing Season

Elk are primarily grazers, preferring grasses and forbs (Kufeld, 1973). They prefer open, wet areas such as wetlands, riparian areas by lakes and streams, marshy meadows, and floodplains but can also be found in a wide range of habitats including coniferous and deciduous forests in all seral stages plus non-forested habitats such as vegetated slides and rock outcrops (Goulet and Haddow, 1985). During the summer, moist, open forests are preferred, and forests with dense canopies receive little use (Peek *et al.,* 1982). Elk often select for the edge between vegetation types (Cairns and Telfer, 1980). In mountainous areas, elk will spend most of the summer at higher elevations foraging in subalpine parkland and alpine tundra.

Winter Season

In winter, elk may use open areas to forage, pawing through the snow to reach grasses and herbs (Hobbs *et al.,* 1981). If the snow crusts or the depth reaches 30 cm or more, elk will move to shrub and conifer forested habitats. Depths of more than 60 cm reduce mobility forcing elk to move to lower elevation forested habitats (RIC, 1997e) where they are forced to shift to a diet of browse, feeding on shrubs and deciduous trees. In the San Juan Mountains, Sweeny and Sweeny (1984) found that snow depths approaching 40 cm caused elk to move to areas with less snow, and depths greater than 70 cm severely limited physical movement. Important winter browse species in the vicinity of the study area are probably willows, aspen, *Prunus* spp., saskatoon, and red-osier dogwood (Goulet and Haddow, 1985).

10.4.3 Security Habitat

Good interspersion of feeding areas and cover is important to elk. Optimal habitat consists of open areas interspersed with patches of trees or dense shrubs. In summer, elk will bed wherever they are finished feeding but always in close proximity to cover (Collins and Urness, 1983). Minimum security cover for elk has been defined as vegetation capable of concealing

90% of a standing elk from view at a distance of 61 m or less (Thomas *et al.,* 1979). The stand's density and diameter of trees and the density of understory vegetation determine its value as security cover (Nyberg and Janz, 1990). Topographical features may also enhance security cover for elk (Nyberg and Janz, 1990). Elevation may also serve as a form of security habitat offering some protection due to reduced numbers of predators at higher elevations. In an area of human disturbance, Morgantini (1979) found that elk would forage within 100 m to 200 m of cover during the day but would move farther into open areas to forage during the night.

10.4.4 Seasons of Use

Table 64 summarizes the rated life requisites for elk for each month of the year.

Table 64: Monthly Rated Life Requisites for Rocky Mountain Elk in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	LI-SH, FD
February	W	LI-SH, FD
March	W	LI-SH, FD
April	W	LI-SH, FD
May	G	LI-SH, FD
June	G	LI-SH, FD
July	G	LI-SH, FD
August	G	LI-SH, FD
September	G	LI-SH, FD
October	W	LI-SH, FD
November	W	LI-SH, FD
December	W	LI-SH, FD

Legend
W=Winter G=Growing LI=Living FD=Food SH=Security
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

10.5 Habitat Use and Ecosystem Attributes

Table 65 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 65: Terrestrial Ecosystem Mapping (TEM) Relationships for Each Life Requisite for Rocky Mountain Elk

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	site: slope, aspect, elevation, structural stage, site disturbance soil/terrain: bedrock, terrain texture, flooding regime vegetation: % cover by layer, species list by layer, cover for each species for each layer
Living Habitat (Security)	site: slope, aspect, elevation, structural stage soil/terrain: terrain texture vegetation: % cover by layer, species list by layer, cover for each species for each layer tree species, dbh, height, CWD

10.6 Development of the Habitat Ratings

10.6.1 Rating Scheme

A 6-Class rating scheme of high (1), moderately high (2), moderate (3), low (4), very low (5), and nil (6) is employed due to the substantial level of knowledge on habitat use of elk (RIC, 1998). The used ratings scheme is defined in Table 66.

Table 66: Habitat Capability and Suitability 6-Class Rating Scheme
(from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	1
75% - 51%	Moderately High	2
50% - 26%	Moderate	3
25% - 6%	Low	4
5% - 1%	Very Low	5
0%	Nil	6

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for Rocky Mountain elk, as previously outlined in Table 63.

10.6.2 Provincial Benchmark

The provincial standard (best in B.C.) for the winter season for the Rocky Mountain elk is the EKT ecosection, IDFdm subzone (within the Southern Interior Mountains ecoprovince), and also the MUF ecosection, SWBmk subzone (within the Northern Boreal Mountains ecoprovince) (RIC, 1998). The provincial standard for the growing season is the MUF ecosection, SWBmk subzone (RIC, 1998).

The southwestern section of the Dunedin study area is located within the MUF ecosection, which is a provincial benchmark for Rocky Mountain Elk for both the growing and winter seasons (RIC, 1998) . The majority of the study area is located within the MUP ecosection which has a moderately high (75% to 51%) capability compared to the standard (RIC, 1998). The Dunedin study area is therefore expected to have quite high capability for elk.

As a smaller scale reference, the Northeastern British Columbia Biophysical Overview Mapping project has assigned Rocky Mountain elk habitat capability ratings for the ecosection/BEC variant combinations found within this region (Table 67) (Habitat Inventory Section, 1994).

Table 67: Ecosection/BEC Variant Combinations for Rocky Mountain Elk Class Values For Habitat Capability Mapping of the Northeastern Portion of B.C.
(Habitat Inventory Section, 1994)

Ecosection	**MUP**		**MUF**		
Variant	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**AT**
Species					
Rocky Mountain Elk	2	3	1	1	2

Legend:
6-class rating scheme: Class 1 - high, Class 2 - moderately high, Class 3 - moderate, Class 4 - low, Class 5- very low and Class 6 - nil value.

10.6.3 Ratings Assumptions

Habitat ratings for elk are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the Rocky Mountain elk's seasonal requirements for feeding and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 65) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- In winter, food value ratings for units may be based primarily on either the presence of preferred food items or on the accessibility of these food items. In deep winter snow conditions, the more open habitats may not be accessible to elk. This model assumes all forested habitats, except shrub and burn units in stage 3, are accessible to elk in the average winter in this region, and food ratings for structural stages 4 to 7 are therefore assigned based on the presence and quantity of preferred forage species. Structural stages 1 to 3 are assumed inaccessible and are thus given low winter food and security ratings. When snow accumulations are low, they may be available to elk, but during more severe winters, snow will preclude access to these sites. These ratings will not be accurate for very mild winters when most habitats are accessible. When snow depths are not restrictive, elk will use more open areas and dig through the snow for vegetation, probably using stage 3 burns and clearcuts in winter when accessible.
- Elk are probably not found in the AT or SWBmks subzones in the winter due to deep restrictive snow depths and lack of cover in these high elevations. Therefore, units in the SWBmks are given a rating of very low or nil and units in the AT are given a rating of nil for winter food and security.
- Warm aspect, generally south-facing slopes are important winter range for elk. In areas of deeper snowpack, elk require denser canopied stands for snow interception. Dense, mature stands with a high conifer component probably become very important in winter when snow depths preclude use of most other habitats. Low-lying areas in the BWBSmw2 along major floodplains (mainly spruce stands) may become important for foraging and cover in winter. Adjacency of good spring range to winter range is important. Floodplains with open deciduous stands in the BWBSmw2 are assumed to green up early, as are warm aspect slopes and avalanche tracks.
- In the growing season, ecosystem units with high proportions of key seasonal food species are rated high for feeding. In general, structural stage 1 has poor foraging value as it is mainly unvegetated. Structural stages 2 to 3 should provide abundant forage and have moderate values for elk if adjacent to cover. Clearcuts should provide moderate summer values, yet elk will probably not forage in the middle of very large clearcuts due to a lack of adjacent cover (especially in areas of human disturbance). Stage 4 to 7 forests should provide good security cover and increase the value of more open feeding areas adjacent to them.
- Riparian stands, vegetated slides, wetlands, and open, deciduous dominated and mixed forests should provide moderate foraging value to elk due to the presence of a good diversity of shrubs and herbs. Open coniferous stands may be used for foraging, and wet sites with abundant growth are favoured throughout the growing season. Very wet units probably have low growing season values. High elevation sites are favoured feeding areas in the summer due to delayed phenology.
- Understory characteristics including shrub composition and density determine the value of units as security habitat. Units with a very sparse understory generally provide only poor security cover. Coniferous shrubs provide better visual screening than deciduous

shrubs in winter. Larger trees provide better security, as does more CWD and structural diversity. Units with dense shrubs receive high security habitat ratings. Structural stages 1 to 2 provide poor security due to the openness of these habitats and receive ratings of nil or very low.

Elk often prefer to forage in the edge habitat between units. This preference cannot easily be addressed in the assumptions section, as ratings are being assigned only to pure ecosystem units, irrespective of the complexity, size and amount of edge of polygons.

10.6.4 Rating Adjustment Considerations

As elk have feeding preferences for edges between habitat types, interspersion of cover and feeding areas is very important in determining habitat use. For example, open feeding areas, e.g. wetlands, will have increased value if they are adjacent to units providing good security habitat, e.g. mature forest.

Proximity to human disturbance will decrease the value of habitats. The presence of roads and associated activities results in significantly decreased elk use in areas adjacent to them (Thomas *et al.,* 1979; Morgantini, 1979). In western Alberta, disturbance caused by a special hunting season forced Rocky Mountain elk off their prime winter range and into poorer quality habitats at higher elevations (Morgantini, 1979).

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11.0 SPECIES – HABITAT MODEL FOR MULE DEER

Common Name:	**Mule Deer**
Scientific Name:	*Odocoileus hemionus hemionus*
Species Code:	M-ODHH
B.C. Status:	Yellow-listed
Identified Wildlife Status:	None
COSEWIC Status:	Not applicable

11.1 Introduction

The information presented in this species-habitat model has been largely extrapolated from other regions as there is little documentation of mule deer habitat associations for this part of British Columbia. There have been no specific mule deer habitat studies, inventories, or surveys completed within the Dunedin study area (B. Webster, *pers. comm.*). Regional information and relevant literature from B.C. and western North America has been incorporated into this species-habitat model where applicable. At this time, general habitat ratings for the mule deer are predicted to have a low reliability as no model verification has been done and mule deer habitat ecology and diet are not well researched in this region of northeastern British Columbia. Before more reliable ratings of habitat value can be developed, data is required on the seasonal food habits and habitat selection of mule deer in this region.

11.2 Distribution

11.2.1 Provincial Range

The mule deer is common throughout most of the province with the exception of the northwestern and north central regions where it occurs only in restricted localities (RIC, 1997d). In 1980, the population of mule deer was estimated to be 100,000 +/- 20% based on limited inventory, known harvests, research findings, and opinions of regional wildlife biologists (Petticrew and Jackson, 1980). Three subspecies of the mule deer are found in British Columbia: the black-tailed deer, Interior mule deer, and Sitka deer (Cannings and Harcombe, 1990). This species-habitat model will concentrate on the habits of the Interior mule deer subspecies, which is the most widely distributed subspecies found throughout the Interior from the Coast mountains east to the Rockies (Banfield, 1987) with high densities in the Kootenay, Caribou, Okanagan and Thompson-Nicola Regions, and in the Peace River area (Petticrew and Jackson, 1980).

11.2.2 Distribution in Study Area

Low numbers of mule deer are present throughout the Dunedin study area (B. Webster, *pers. comm.*). Mule deer are found within all of the ecoregions, ecosections, and biogeoclimatic zones found within the Dunedin study area, as summarized in Table 68.

Table 68: Expected Mule Deer Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	TAIGA PLAINS		NORTHERN BOREAL MOUNTAINS			
Ecoregions	Muskwa Plateau		Northern Canadian Rocky Mountains			
Ecosections	MUP		MUF			
BEC Variants	BWBSmw2	BWBSwk3	BWBSmw2	SWBmk	SWBmks	AT
Species						
Mule Deer	•	•	•	•	•	•

Legend:
- = occurs in the variant

11.2.3 Elevational Range

Elevations within the study area range from approximately 250 m to 2,105 m. Mule deer may be found from the BWBS zone up to the AT zone within the study area.

11.3 Ecology and Habitat Requirements

Mule deer are broadly adapted to many habitats and prefer open coniferous forests. Generally, habitat use ranges from higher elevation moister areas such as parkland and wet meadows in the summer to lower elevation sites during the winter. Preferred winter range has abundant forage (usually riparian habitats) interspersed with mature stands having high canopy closure (Stevens and Lofts, 1988).

A lack of adequate deer winter range is probably the main factor limiting the deer population in this area. Snow depth is probably a major factor limiting deer distribution, and severe winters may be very hard on populations within the study area. High winter mortality is probable due to winter stresses and heavy wolf predation (J. Hart, *pers. comm.*). Bad winters are reported to be very hard on the deer populations within the area (J. Hart, B Webster, *pers. comms.*).

11.4 Habitat Use (Life Requisites and Seasons)

Mule deer habitat use for the study area is broken down into two seasons – growing and winter. Life requisites that are rated for mule deer include living, feeding, and security, as summarized in Table 69.

Table 69: Summary of Rated Life Requisites and Seasons for Mule Deer in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use
Living during the growing season - food Living during the growing season - security	LI_G_FD LI_G_SH	May-September
Living during the winter season - food Living during the winter season - security	LI_W_FD LI_W_SH	October-April

Habitats used for reproduction (birthing) and rutting have not been rated as there is insufficient information available to distinguish these habitats. Mule deer are thought to calve in May within the Fort Nelson area, and the rut is speculated to occur in early to mid October (J. Hart, *pers. comm.*).

Rated life requisites are described in detail below. Additional information on mule deer thermal habitat requirements has also been included, although thermal habitat was not rated.

11.4.1 Living

Mule deer generally migrate seasonally, moving to summer ranges at upper elevations and down to lower elevation winter ranges in the fall (Petticrew and Jackson, 1980). They may also remain at lower elevations throughout the year.

11.4.2 Feeding

Growing Season

The mule deer has a diverse diet including a variety of grasses, forbs, shrubs, trees, sedges, agricultural crops, mushrooms, and lichens depending on season (Petticrew and Jackson, 1980). Succulent forbs are the most preferred forage yet are available only during spring and summer (Holroyd and Tighem, 1983). Mule deer are generally found in areas of high vegetational heterogeneity (Morgantini, 1979). Early and intermediate seral stages after burning or logging often provide abundant foods and are good growing season habitats providing sufficient security cover is available. Deer are rarely found in dense woods. They may be found in variety of landform types and generally inhabit steeper and more broken terrain than do white-tailed deer (Luttmerding *et al.,* 1990).

Adjacency of early spring range to winter range is critical. Steep south-facing slopes are often the first areas to green up in early spring (Luttmerding *et al.,* 1990). Herbaceous open areas and floodplain forests may also be important spring areas.

Winter Season

In winter, deer move to lower elevations, warm aspect slopes, or to exposed ridges where snowpacks are low (Armeleder *et al.,* 1994). Low snow depths are a very important factor of winter range as snow depths of only 50 cm can cause an increase in the energy cost of locomotion of mule deer by 498% compared with bare ground (Parker *et al*., 1984). Snow depths greater than 40 cm are considered to greatly restrict physical movement of deer (Kelsall, 1969). In severe winters with deep snowpacks, mature coniferous forests with a high degree of crown closure are very important to provide cover, forage, and reduced snow depth.

Winter forage is mainly comprised of shrubs and litterfall with shrubs being preferred but not necessarily available on most winter ranges (Waterhouse *et al.,* 1994). Shrubs are more available and are consumed in higher proportions under shallow snow conditions (Madrone Consultants Ltd., 1997). Arboreal lichens (*Usnea spp*., *Alectoria* spp., and *Bryoria* spp.) are also an important winter food item (where they occur) obtained mainly as litterfall (Madrone Consultants Ltd., 1997). Stands over 100 years old generally provide more litterfall than younger ones (Waterhouse *et al.,* 1991). Arboreal lichens were found to compose up to 12% of the winter diet of deer in the Cariboo Region (Waterhouse *et al.,* 1991). Further south of the study area in the central interior of B.C., the key winter food is Douglas-fir foliage, which can compose up to 89% of the mule deer's diet (Dawson *et al.,* 1990). However, in the Dunedin study area, important winter browse species are probably saskatoon, red-osier dogwood, and willows (Goulet and Haddow, 1985).

11.4.3 Security Habitat

Interspersion of food and cover is very important in determining deer habitat quality. Optimal habitat consists of open areas interspersed with forests. Minimum security cover for mule deer has been defined as vegetation capable of concealing 90% of a deer from view at a distance of 60 m or less (Thomas *et al.,* 1979). The stand's density and diameter of trees and the density of understory vegetation determine its value as security cover (Nyberg and Janz, 1990). Tree boles and foliage provides the best cover, yet short, dense vegetation and CWD can provide adequate screening in some areas (Nyberg and Janz, 1990). In flat terrain, small trees 1 to 2 m in height can provide effective security cover; in broken terrain, both large and small trees can provide effective cover (Armeleder and Dawson, 1992). Security cover also reduces deer energy expenditure by reducing the need and the distance to flee (Armeleder and Dawson, 1992; Armeleder *et al.,* 1986).

11.4.4 Thermal Habitat/Bedding

Multi-layered stands provide the best thermal habitat as they protect deer from the chill factor associated with low temperature and increasing wind speed much more effectively than do single-layered, even-aged stands (Armeleder *et al.,* 1986; Thomas *et al.,* 1979). A mix of trees 1 to 10 m in height is effective at reducing air movement at deer level (Armeleder and Dawson, 1992; Thomas *et al.,* 1979). In the summer, closed canopies of various coniferous stands provide shade if required. Mule deer generally use specific bed sites and will return to them repeatedly (Collins and Urness, 1983).

11.4.5 Seasons of Use

Table 70 summarizes the rated life requisites for mule deer for each month of the year.

Table 70: Monthly Rated Life Requisites for Mule Deer in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	LI-SH, FD
February	W	LI-SH, FD
March	W	LI-SH, FD
April	W	LI-SH, FD
May	G	LI-SH, FD
June	G	LI-SH, FD
July	G	LI-SH, FD
August	G	LI-SH, FD
September	G	LI-SH, FD
October	W	LI-SH, FD
November	W	LI-SH, FD
December	W	LI-SH, FD

Legend:
W=Winter G=Growing LI=Living FD=Food SH=Security
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

11.5 Habitat Use and Ecosystem Attributes

Table 71 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 71: Terrestrial Ecosystem Mapping (TEM) Relationships for Each Life Requisite for Mule Deer

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	site: slope, aspect, elevation, structural stage, site disturbance soil/terrain: bedrock, terrain texture, flooding regime vegetation: % cover by layer, species list by layer, cover for each species for each layer
Living Habitat (Security)	site: slope, aspect, elevation, structural stage soil/terrain: terrain texture vegetation: % cover by layer, species list by layer, cover for each species for each layer tree species, dbh, height, CWD

11.6 Development of the Habitat Ratings

11.6.1 Rating Scheme

A 6-Class rating scheme of high (1), moderately high (2), moderate (3), low (4), very low (5), and nil (6) is employed due to the substantial level of knowledge on habitat use of mule deer (RIC, 1998). The used ratings scheme is defined in Table 72.

Table 72: Habitat Capability and Suitability 6-Class Rating Scheme (from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	1
75% - 51%	Moderately High	2
50% - 26%	Moderate	3
25% - 6%	Low	4
5% - 1%	Very Low	5
0%	Nil	6

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for mule deer, as previously outlined in Table 69.

11.6.2 Provincial Benchmark

The provincial standard (best in B.C.) for the winter season for the mule deer is the FRB ecosection, IDFxm subzone (within the Central Interior ecoprovince) and also the EKT ecosection, IDFdm subzone (within the Southern Interior Mountains ecoprovince) (RIC, 1998). The provincial standard for the growing season is the EPM ecosection, ESSFdk subzone (within the Southern Interior Mountains ecoprovince).

The two ecosections (MUP and MUF) found within the Dunedin study area each have a moderate (50% to 26% of standard) capability compared to the standard (RIC, 1998). The

Dunedin study area is therefore expected to have an overall moderate capability for mule deer.
As a smaller scale reference, the Northeastern British Columbia Biophysical Overview Mapping project has assigned mule deer habitat capability ratings for the ecosection/BEC variant combinations found within this region (Table 73) (Habitat Inventory Section, 1994).

Table 73: Ecosection/BEC Variant Combinations for Mule Deer
Class values for habitat capability mapping of the northeastern portion of B.C.
(Habitat Inventory Section, 1994)

Ecosection	MUP		MUF		
Variant	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**AT**
Species					
Mule Deer	3	4	3	4	5

Legend:
6-class rating scheme: Class 1 - high, Class 2 - moderately high, Class 3 - moderate, Class 4 - low, Class 5- very low and Class 6 - nil value.

11.6.3 Ratings Assumptions

Habitat ratings for mule deer are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the mule deer's seasonal requirements for feeding and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 71) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- In winter, food value ratings for units may be based primarily on either the presence of preferred food items or on the accessibility of these food items. Deer are quite susceptible to snow depths, as depths greater than 40 cm are considered to limit deer movement (Kelsall, 1969). Therefore, in deep winter snow conditions, the more open habitats will not be accessible to deer. This model assumes all habitats in stage 1 to 4 are inaccessible to deer in the average winter snow conditions for this region. They are therefore given low food and security ratings regardless of the forage species present. These ratings will not be accurate for very mild winters when some habitats in the lower structural stages may be accessible to deer.
- Mule deer are probably not found in the AT or SWBmks subzones in the winter due to deep restrictive snow depths and lack of cover in these high elevations. Therefore, units in the SWBmks are given a rating of very low or nil and units in the AT are given a rating of nil for winter food and security.
- Warm aspect, generally south-facing slopes are important winter range for deer. In areas of deeper snowpack, deer require denser canopied stands for snow interception. Dense, mature stands with a high conifer component probably become very important in winter when snow depths preclude use of most other habitats. Low-lying areas in the BWBSmw2 along major floodplains (mainly spruce stands) probably become important for foraging and cover in winter. Mature stages should also provide greater production and litterfall of arboreal lichens. Adjacency of good spring range to winter range is important. Floodplains with open deciduous stands in the BWBSmw2 are assumed to green up early, as are warm aspect slopes.

- In the growing season, ecosystem units with high proportions of key seasonal food species are rated high for feeding. In general, structural stage 1 has poor foraging value as it is mainly unvegetated. Structural stages 2 to 3 should provide abundant forage and have good growing season values for deer if adjacent to cover. Clearcuts should provide moderate to high feeding values, yet mule deer probably will not forage in the middle of large clearcuts due to the lack of adjacent cover. Deer will generally only forage within 200 m of cover. Structural stages 4 to 7 should provide good security cover and increase the value of more open feeding areas adjacent to them.
- Riparian stands, open deciduous dominated, and mixed forests should provide moderate value to deer in the growing season due to good diversity and abundance of shrubs and herbs. Coniferous forests generally have low foraging value in the growing season as these stands generally have less diversity and less forage available. Very wet units probably have low growing season values as deer are unlikely to be using these sites. Higher elevation sites are favoured feeding areas in the summer due to delayed phenology.
- Understory characteristics including shrub composition and density determine the value of units as security habitat. Units with a very sparse understory generally provide only poor security cover. Coniferous shrubs provide better visual screening than deciduous shrubs in winter. Larger trees provide better security, as does more CWD and structural diversity. Units with dense shrubs receive high security habitat ratings. Structural stages 1 to 2 provide poor security due to the openness of these habitats and receive ratings of nil or very low.

11.6.4 Rating Adjustment Considerations

Interspersion of cover and feeding areas is very important in determining habitat use of mule deer. For example, open feeding areas, e.g. cutblocks, will have increased value if they are adjacent to units providing good security habitat, e.g. mature forest. Patchy landscapes with relatively high forest to opening edge ratios will have increased value.

Warm aspect units will have increased value in the winter.

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12.0 SPECIES – HABITAT MODEL FOR MOOSE

Common Name: **Moose**
Scientific Name: *Alces alces*
Species Code: M-ALAL
B.C. Status: Yellow listed
Identified Wildlife Status: None
COSEWIC Status: Not applicable

12.1 Introduction

Moose habitat ecology and diet have been well researched for most of British Columbia and the United States. However, there have been no specific moose habitat studies or inventories within the Dunedin study area (B. Webster, *pers. comm.*) and only limited moose research within northeastern B.C. Regional information has been included in the species-habitat model where possible, and relevant literature from B.C. and western north America has been included. At this time, general habitat ratings for the moose are predicted to have a low to moderate reliability as no model verification has been done.

12.2 Distribution

12.2.1 Provincial Range

Moose are found throughout British Columbia except for the coastal islands and the grasslands of the southern interior (Eastman and Ritcey, 1987). The moose is also found in all of the biogeoclimatic zones in the province; although, "the species occurs only intermittently in the Coastal Western Hemlock and adjacent Mountain Hemlock biogeoclimatic zones and is not a regular resident of unforested or sparsely forested zones in the interior (e.g., Alpine Tundra, Bunchgrass, and probably Ponderosa Pine)" (RIC, 1997d). The British Columbia population of moose was estimated at about 240,000 moose in 1979 (B.C. Ministry of Environment, Fish and Wildlife Branch, 1979).

12.2.2 Distribution in Study Area

Moose are widespread and the most common ungulate within the Dunedin study area. On a provincial basis, the relative abundance of moose is rated as moderate (1 moose per 1.3 to 10 sq. km) over the entire Dunedin study area (Fish, Wildlife and Habitat Protection Department, 1994). Moose are present within all three biogeoclimatic zones found within the study area, although they are not a regular resident of the AT zone (RIC, 1997d). Moose occur within all of the ecoregions, ecosections, and biogeoclimatic zones found within the Dunedin study area, as summarized in Table 74.

Table 74: Expected Moose Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	**TAIGA PLAINS**		**NORTHERN BOREAL MOUNTAINS**			
Ecoregions	**Muskwa Plateau**		**Northern Canadian Rocky Mountains**			
Ecosections	**MUP**		**MUF**			
BEC Variants	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**SWBmks**	**AT**
Species						
Moose	•	•	•	•	•	•

Legend: • = occurs in the variant

12.2.3 Elevational Range

Elevations within the study area range from approximately 250 m to 2,105 m. Moose may be found from the BWBS zone up to the AT zone.

12.3 Ecology and Habitat Requirements

Moose are the most common ungulate within the study area and frequently use riparian areas and areas of disturbance, especially those habitats that are characterized by early seral stages in forest maturation.

Moose may migrate between summer and winter ranges or they may remain resident during the winter if habitat needs can be met. Moose in winter prefer areas with abundant willows and deciduous sub-climax vegetation typical of disturbed sites such as regenerating cutblocks, shrubby burns, wetlands, and floodplains (Decker and Mackenzie, 1980). In more mountainous areas, they may also occupy deciduous forests and shrub lands on steep, south-facing slopes (Eastman and Ritcey, 1987).

Winter snow conditions in years of record snowfall impose many limitations on moose including reduced mobility, concentration of animals on restricted ranges, limited foraging opportunities, or increased risk of highway and railway collisions. Due to the impacts of snow accumulations on both moose habitat use and behaviour, the following discussion on moose and snow is included in this model.

Moose can tolerate deep snow handling depths of 40 to 50 cm without difficulty; depths of 60 cm to 70 cm impedes movement, and depths of greater than 100 cm severely restrict movement (Langin and Eastman, 1990). Moose will generally move out of areas where snow depths exceed 70 cm (RIC, 1997e). During deep snow periods, moose prefer habitat characterized by dense coniferous cover (Eastman, 1974, cited in Silver, 1976; Pierce and Peek, 1984b; Telfer, 1970). In severe winters when snow accumulation precludes use of more open habitats, moose may require key areas of coniferous cover (mature timber) generally in low-lying areas, river valleys, and floodplains providing relatively shallow snow depths and abundant browse. In the Cameron River area within the boreal Black and White Spruce Zone, Silver (1976) found that moose did not shift to coniferous stands in late winter as commonly observed in other parts of western North America as snow depths rarely exceeding 76 cm were not restrictive. Open shrub land and deciduous forest were preferred winter habitat in this area (Silver, 1976). Winter surveys by Goulet and Haddow (1985) in the Liard River Valley of B.C. (to the north of the study area) found that moose preferred sub-alpine, burns, and riparian/alluvial habitats characterized by the presence of abundant shrubby vegetation where willows (and red-osier dogwood for the alluvial types) were abundant. A winter survey conducted under heavy snow conditions over a large area in northeastern B.C. recorded 70% of observed moose in the valley bottoms in riparian habitats and cutblocks with the remaining 30% observed in uplands situations. Of these, 50% to 60% of the moose were in concentrated areas in cutblocks or old burns in the uplands with the rest very widely distributed in the uplands (B. Webster, *pers. comm.*). Many important moose winter ranges (Class 1) are found in riparian areas adjacent to large rivers (D. Becker, *pers. comm.* 1998). Moose may congregate on islands in severe winters when winds may keep them more snow free (Decker and Mackenzie, 1980; Jingfors *et al.,* 1987).

12.4 Habitat Use (Life Requisites and Seasons)

Moose habitat use for the study area is broken down into two seasons – growing and winter. Life requisites that are rated for moose include living, feeding, and security, as summarized in Table 75.

Table 75: Summary of Rated Life Requisites and Seasons for Moose in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use
Living during the growing season - food Living during the growing season - security	LI_G_FD LI_G_SH	May-September
Living during the winter season - food Living during the winter season - security	LI_W_FD LI_W_SH	October-April

Habitats used for reproduction (birthing) and rutting have not been rated and are therefore not included in the previous table. Within the Fort Nelson area, moose generally calve in May and the rut generally occurs in the last two weeks of September (J. Hart, *pers. comm.*).

Rated life requisites are described in detail below. Additional information on moose reproduction and thermal habitat requirements has also been included.

12.4.1 Living

Moose are generally associated with riparian habitats, wetlands, shrub lands, and deciduous forests (RIC, 1997e). Riparian communities and early seral stages following fire or other disturbance are considered to be prime moose habitat (Kelsall and Telfer, 1974, in Cairns and Telfer, 1980). From RIC (1997d), Geist (1971) referred to the "shrub communities within forested areas (e.g., along watercourses and in the subalpine zone) as "permanent" moose habitats and labelled the new secondary successional communities following major disturbances (e.g., fire) as "transient" moose habitats. Permanent habitats are important in their support of moose populations between the transient habitats both spatially and temporally, but the really conspicuous increases and maintenance of large numbers of moose generally occur in the latter (Edwards, 1954; Peek, 1974b)."

12.4.2 Feeding

Growing Season

Throughout the growing season, the diet of moose includes aquatic vegetation, forbs, grasses and the leaves of many of the shrubs also consumed in winter. In the Liard River Valley of B.C., moose were found to prefer the following browse species during the summer: willows, bog birch, trembling aspen, green alder, paper birch, and high bush cranberry (Goulet and Haddow, 1985). Red-osier dogwood, wild rose, thin-leaved alder, balsam poplar, and common saskatoon were used in proportion to availability. Numerous non-browse species are also important in the summer diet of moose including forbs, grasses, sedges, and aquatics (LeResche and Davis, 1973; Ritcey and Verbeek, 1969; Peek, 1974a). Aquatic plants appeared to form the bulk of the summer diet in Bowron Lake Park, B.C. (Ritcey and Verbeek, 1969). Moose are rarely found in dense forest during the summer; they generally prefer wetlands and the margins of lakes and streams.

Winter Season

Moose are primarily browsers in the winter, foraging on the twigs of shrubs and trees. There is limited information on specific food habits of moose for northeastern B.C. (Eastman and Ritcey, 1987). Silver (1976) found that, in the Cameron River area within the Boreal Black and White Spruce Zone, the most important winter browse species included willow, aspen, and bog birch with willow comprising over 50% of the winter diet. Winter browse surveys in the Liard river valley to the immediate north of the Dunedin study area found willows and red-osier dogwood to be highly preferred (Goulet and Haddow, 1985). Winter browse surveys in the MacKenzie Valley, Northwest Territories, also show moose to prefer successional species with willow, balsam poplar, and red osier dogwood making up over 90% of the diet and willow over 50% of the total winter diet (Walton-Rankin, 1977, in Decker and Mackenzie, 1980). Aspen and birch are also preferred browse species when available. Willows have been found to be the most preferred forage species in northeastern British Columbia (Silver, 1976; Goulet and Haddow, 1985).

12.4.3 Security Habitat

Moose rely on forested cover rather than terrain for escape habitat (Luttmerding *et al.,* 1990). There is no operational definition of security cover for moose (Langin and Eastman, 1990) but as an example Thomas *et al.* (1979) defined minimum security cover for Rocky Mountain elk as vegetation capable of concealing 90% of a standing elk from view at a distance of 61 m or less. Cover adjacent to open feeding areas is important throughout the year. Dense stands of young conifers provide good security cover (Langin and Eastman, 1990) as do older stands depending on the stand's density, diameter of trees, and density of understorey vegetation (Nyberg and Janz, 1990). Elevation may also serve as a form of security habitat offering some protection due to reduced numbers of predators at higher elevations.

12.4.4 Thermal Habitat

During summer, moose will use forested and wetland areas to reduce heat stress. In more mountainous areas on cold, sunny winter days, moose will utilize warm aspect (southerly) slopes to gain solar benefits; conversely, on warmer winter days, they will move to cooler habitats to avoid thermal stress (D. Becker, *pers. comm.*).

12.4.5 Reproduction

Islands and shrubby lake borders are important for calving grounds in spring within the Liard Valley, Northwest Territories (Decker and Mackenzie, 1980). Based on his communications with residents in the area, J. Hart (*pers. comm.*) also feels that moose calve on islands in the Fort Nelson area where they are more likely to avoid predation from wolves. In the Cameron

River area of northeastern B.C., Silver (1976) found cows to use coniferous stands in and near watercourses for calving.

12.4.6 Seasons of Use

Table 76 summarizes the rated life requisites for moose for each month of the year.

Table 76: Monthly Rated Life Requisites for Moose in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	LI-SH, FD
February	W	LI-SH, FD
March	W	LI-SH, FD
April	W	LI-SH, FD
May	G	LI-SH, FD
June	G	LI-SH, FD
July	G	LI-SH, FD
August	G	LI-SH, FD
September	G	LI-SH, FD
October	W	LI-SH, FD
November	W	LI-SH, FD
December	W	LI-SH, FD

Legend
W=Winter G=Growing LI=Living FD=Food SH=Security
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

12.5 Habitat Use and Ecosystem Attributes

Table 77 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 77: Terrestrial Ecosystem Mapping (TEM) Relationships for Each Life Requisite for Moose

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	site: slope, aspect, elevation, structural stage, site disturbance soil/terrain: bedrock, terrain texture, flooding regime vegetation: % cover by layer, species list by layer, cover for each species for each layer
Living Habitat (Security)	site: slope, aspect, elevation, structural stage soil/terrain: terrain texture vegetation: % cover by layer, species list by layer, cover for each species for each layer mensuration: tree species, dbh, height CWD

12.6 Development of the Habitat Ratings

12.6.1 Rating Scheme

A 6-Class rating scheme of high (1), moderately high (2), moderate (3), low (4), very low (5), and nil (6) is employed due to the substantial level of knowledge on habitat use of moose (RIC, 1998). The used ratings scheme is defined in Table 78.

Table 78: Habitat capability and suitability 6-class rating scheme (from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	1
75% - 51%	Moderately High	2
50% - 26%	Moderate	3
25% - 6%	Low	4
5% - 1%	Very Low	5
0%	Nil	6

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for moose, as previously outlined in Table 75.

12.6.2 Provincial Benchmark

The provincial standard (best in B.C.) for both the winter and growing seasons for the moose is the PEL ecosection, BWBSmw subzone, within the Boreal Plains Ecoprovince (RIC, 1998).

The two ecosections (MUP and MUF) found within the Dunedin study area each have a high (76% to 100% of standard) capability compared to the standard (RIC, 1998). The Dunedin study area is therefore expected to have an overall high capability for moose.

As a smaller scale reference, the Northeastern British Columbia Biophysical Overview Mapping project has assigned moose habitat capability ratings for the ecosection/BEC variant combinations found within this region (Table 79) (Habitat Inventory Section, 1994).

Table 79. Ecosection/BEC Variant Combinations for Moose
Class values for habitat capability mapping of the northeastern portion of B.C.
(Habitat Inventory Section, 1994)

Ecosection	**MUP**		**MUF**		
Variant	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**AT**
Species					
Moose	1	3	1	1	3

Legend:
6-class rating scheme: Class 1 - high, Class 2 - moderately high, Class 3 - moderate, Class 4 - low, Class 5- very low and Class 6 - nil value.

12.6.3 Ratings Assumptions

Habitat ratings for moose are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the moose's seasonal requirements for feeding and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 77) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- In winter, food value ratings for units may be based primarily on either the presence of preferred food items or on the accessibility of these food items. This model assumes all habitats were accessible to moose in winter as they can tolerate deep snow, and therefore ratings are assigned on the basis of presence and abundance of forage species. These ratings will not be accurate for severe winter conditions when some habitats in the lower structural stages are inaccessible due to restrictive snow depths.
- Moose are probably not found in the AT or SWBmks subzones in the winter due to the deeper snow depths and lack of cover in these high elevations. Therefore, units in the SWBmks are given a rating of very low or nil and units in the AT are given a rating of nil for winter food and security.
- In severe winters, mature coniferous-dominated units may become very important when low-lying areas with reduced snow depth become important for foraging. They have higher foraging values when snow depths in more open areas are restrictive. The SH/05 ecosystem probably has very high value in severe winters within the BWBS. However, it is assumed in this model that snow depths are seldom restrictive for moose in this region.
- In winter, vegetation types supporting an abundant growth of willows receive the most use by moose (Goulet and Haddow, 1985). Units with an abundance of preferred shrub species (especially willow) are rated high all year due to the value of foliage in the growing season and twigs in the winter. Structural stage 3 cutblocks, shrub lands, or burns with deciduous regrowth, riparian edges, and Willow-Alder units have high feeding value. In general, structural stage 1 has poor foraging value as it is mainly unvegetated.
- Open deciduous and mixed wood forests in structural stages 4 to 7 probably have moderate to high value in the growing season. Coniferous forest generally have lower values due to lower shrub and herb development, yet stage 6 or 7 stands with canopy openings can provide good forage. Coniferous forests provide good thermal and security cover during winter. They may also be used for travel due to reduced snow depths.
- Wetlands and areas around ponds are rated very high in the growing season for foraging. Floodplains, Sedge-Grass wetlands, and south slopes may provide the first high quality food in spring due to the early green up of these areas.
- Understory characteristics including shrub composition and density determine the value of units as security habitat. Units with a very sparse understory generally provide only poor security cover. Coniferous shrubs provide better visual screening than deciduous shrubs in winter. Larger trees provide better security, as does more CWD and structural diversity. Units with dense shrubs receive high security habitat ratings. Structural stages 1 to 2 provide poor security due to the openness of these habitats and receive ratings of nil or very low.

12.6.4 Rating Adjustment Considerations

Interspersion of cover and feeding areas is very important in determining moose habitat use. For example, open feeding areas, e.g. wetlands, will have increased value if they are adjacent to units providing good security habitat, e.g. mature forest. Patchy landscapes with relatively high forest to opening edge rations will have increased value.

Warm aspect units will have increased value in the winter.

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13.0 SPECIES – HABITAT MODEL FOR STONE'S SHEEP

Common Name:	**Stone's Sheep**
Scientific Name:	*Ovis dalli stonei*
Species Code:	M-OVDA
B.C. Status:	Blue-listed (B.C. MoELP, 1996; B.C. CDC, 1997)
Identified Wildlife Status:	None
COSEWIC Status:	Not applicable

13.1 Introduction

Information from two studies completed within northeastern B.C. (Seip, 1983 and Luckhurst, 1973) has been incorporated into this species habitat-model. There have been no specific Stone's sheep habitat studies or inventories within the Dunedin study area (B. Webster, *pers. comm.*). Mountain sheep habitat ecology and diet have been well researched for most of British Columbia and the United States, and relevant literature from B.C. and western north America has been included in this species-habitat model. At this time, general habitat ratings for the Stone's sheep are predicted to have low reliability as no model verification has been done.

13.2 Distribution

13.2.1 Provincial Range

The Stone's sheep, a subspecies of thinhorn sheep (*Ovis dalli*), inhabits mountainous areas of northern British Columbia and the southern Yukon (Seip, 1983). The world population of Stone's sheep occurs only in British Columbia and the Yukon with approximately 75% of the world's population living in B.C. (B.C. Ministry of Recreation and Conservation, 1978). Populations of Stone's sheep are found on the Yukon and Stikine Plateaus, the Skeena, Cassiar and Omineca Mountains, the Rocky Mountains from the Pine river to the Liard River, and the Boundary Ranges of the Coast Mountains (B.C. Ministry of Recreation and Conservation, 1978). The British Columbia population of Stone's sheep was estimated at 12,000 $\pm$ 1,200 sheep in 1978 (B.C. Ministry of Recreation and Conservation, 1978).

13.2.2 Distribution in the Study Area

Stone's Sheep do not regularly occur in the Taiga Plains ecoprovince, and within the Dunedin study area, they are expected to be found only in the Northern Boreal Mountains Ecoprovince, MUF ecosection, located in the southwest corner of the study area.

Relative abundance of sheep is rated as moderate (1 sheep per 1.3 km^2 to 5 km^2) over the lower portion of the study area. The area immediately surrounding Stone Mountain Park has a plentiful rating of over 1 sheep per 1.3 km^2 (Fish, Wildlife and Habitat Protection Department, 1994). The lower eastern ridge of the study area is rated as few (1 sheep per 5 km2 to 250 km^2) sheep present (Fish, Wildlife and Habitat Protection Department, 1994).

Stone's sheep occurrence within the ecoregions, ecosections, and biogeoclimatic zones of the study area is summarized in Table 80.

Table 80: Expected Stone's Sheep Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	TAIGA PLAINS		NORTHERN BOREAL MOUNTAINS			
Ecoregions	Muskwa Plateau		Northern Canadian Rocky Mountains			
Ecosections	MUP		MUF			
BEC Variants	BWBSmw2	BWBSwk3	BWBSmw2	SWBmk	SWBmks	AT
Species						
Stone's Sheep	?	?	•	•	•	•

Legend:
- = occurs in the variant

•? = probably occurs in the variant

? = unlikely to occur in the variant

13.2.3 Elevational Range

Within the study area, Stone's sheep are found from the AT zone down to the BWBS zone (approx. 2,105 m to 250 m), although most of their time will be spent at the upper elevations.

13.3 Ecology and Habitat Requirements

Stone's sheep generally occur above tree line in the northern Rocky Mountains (Luckhurst, 1973). They inhabit open areas in mountainous terrain with steep terrain used for escape. Stone's Sheep are limited to foraging areas near to escape terrain. Typically, sheep depend on several seasonal ranges to which they show a great fidelity and which may be separated by great distances (Geist, 1971).

Usually, Stone's sheep separate into ram and ewe-juvenile groups that tend to occupy distinct home ranges over the year (Luckhurst, 1973). In the late fall and early winter during the rut, the rams leave their summer home range and travel to ewe-juvenile ranges where they spend part of the winter (Luckhurst, 1973).

Stone's sheep occupy high summer alpine range, and with the first autumn snows, they move down to feed on lower alpine slopes with a warm exposure (Luckhurst, 1973). As upper slopes and ridges are swept free of snow, sheep move to these sites and feed on the often sparse vegetation of these sites (Luckhurst, 1973).

13.4 Habitat Use (Life Requisites and Seasons)

Stone's sheep habitat use for the study area is broken down into two seasons – growing and winter. Life requisites that are rated for Stone's sheep include living, feeding, and security, as summarized in Table 81.

Table 81: Summary of Rated Life Requisites and Seasons for Stone's Sheep in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use	Comments
Living during the growing season - food Living during the growing season - security	LI_G_FD LI_G_SH	May-September	- Movements to seasonal ranges - exploiting phenology of plants
Living during the winter season - food Living during the winter season - security	LI_W_FD LI_W_SH	October-April (February to March most critical time)	- Snow free alpine peaks and ridges form core winter range - winter range is limiting due to snow depth conditions

Ecosystem units were not rated for security and feeding values for Reproducing (RB) as birthing habitat is not well defined for Stone's Sheep. Birthing generally occurs in late May to early June usually in areas of steep rocky terrain (Luckhurst, 1973). Winter thermal values were not rated because Stone's Sheep are primarily selecting for regions of low snow depth and available forage. Winter thermal habitat is therefore assumed to be the same as winter security habitat.

Rated life requisites are described in detail below. Additional information on mineral licks and migration routes has also been included.

13.4.1 Living

The living life requisite for Stone's sheep is satisfied by the presence of suitable feeding and security habitat and access to mineral licks and to migration routes, which are described in detail below.

13.4.2 Feeding

The following feeding account is synthesized from Seip (1983). Seip's study was conducted in the vicinity of Toad River in two areas to the immediate west and southwest of the Dunedin study area. Therefore, sheep foraging within the Dunedin study area is expected to be similar to that found by Seip (1983).

Growing Season

Spring range consists of low elevation (1,200 m to 1,500 m) subalpine clearings including avalanche chutes, streamsides, talus slopes, rockslides, and burns (Seip, 1983). Sheep descend to these clearings in late April and forage on subalpine grasses *(E. innovatus* and *Poa* spp. important) and browse (including conifers) (Seip, 1983). A gradual migration up to summer range occurs with sheep moving from the subalpine clearings in May and reaching high alpine by July, paralleling the green-up of the vegetation (Seip, 1983). Typically at this time, there is a decrease in the use of grasses and an increased use in forbs (especially locoweed), willows, and poplars (Seip, 1983).

By July, Stone's sheep have reached their high alpine summer range and begin feeding on newly emergent vegetation. Sedges are the most important forage species with a wide variety of forbs and browse (willows important) being utilized (Seip, 1983). Sheep may use subalpine mineral licks and return to the alpine for foraging or they may use lower elevation licks (Seip, 1983).

In the fall, Stone's sheep are less selective in their habitat preferences due to declining forage quality (Seip, 1983). Sheep will utilize a wide variety of range types from high alpine slopes to burned, subalpine slopes. *Poa* spp. of grasses is heavily used throughout the year on subalpine and alpine ranges. Yarrow (*Achillea*) and locoweed also predominate in the diet (Seip, 1983).

Winter Season

Stone's Sheep (to the immediate west of the Dunedin study area) use windswept mountain peaks and ridges as winter range at elevations of 1,500 to 2,200 m (Seip, 1983). The critical characteristic of winter range is that the area be blown free of snow as Stone's sheep are restricted to areas with snow accumulation of less than 25 cm to 30 cm (Seip, 1983). These areas are generally very limited. In a survey by Seip (1983) of 1,000 square km, all the sheep located were using a total of less than 3 square km. In years of low snowfall, lower subalpine slopes may be available for use as winter range, but these will be inaccessible in typical winters. Vegetation is very sparse on wind-swept alpine peaks and Stone's sheep feed largely on sedges (*Carex* spp.), grasses (blue grass - *Poa* spp. important) and lichens, with forbs making up a small part of the winter diet (Seip, 1983).

13.4.3 Security Habitat

Escape terrain is a very important habitat requirement for Stone's sheep. Typical escape habitat includes cliffs, rock outcroppings, and bluffs often with sparse cover of trees or shrubs that provide both thermal and hiding cover. Talus slopes may also be used as a form of escape cover. Steep escape terrain (slopes >100%) must be within 0.5 km of feeding areas (Luttmerding *et al.,* 1990). While sheep are not always found in precipitous escape terrain, ewes and lambs rely heavily on these areas, especially during the lambing period (Lawson and Johnson, 1982). Elevation also serves as security habitat as higher elevations will afford protection from many terrestrial and aerial predators.

Good visibility is important for Stone's sheep allowing for predator detection, visual communication, and efficient foraging. Wild sheep select ranges where their view is unrestricted by standing timber, high shrubs, brush, or other obstructions (B.C. MoELP, 1997)

Stone's Sheep will not generally bed or forage farther than 200 m from rugged escape terrain (D. Seip, *pers. comm.*). Foraging habitat must be near enough to escape habitat for it to be used. They will travel further from escape habitat to travel to new feeding sites or to mineral licks.

13.4.4 Mineral Licks

Mineral licks are an important but localized feature for Stone's Sheep. Licks are used primarily from April to July but may be used year round (Seip, 1983). Luckhurst (1973) found Stone's sheep to use mineral licks heavily in the early fall in addition to use in the late spring. Many forms of licks exist including soil licks exposed along creek beds and road cuts and weathered, rocky outcrops (Seip, 1983). Sheep may make long excursions to reach these mineral licks and remain in unsuitable habitat to utilize licks (Tankersley, 1984, *in* Festa-Bianchet, 1986).

13.4.5 Migration Routes

Sheep will follow the same paths year after year often making well defined trails as they move between traditional seasonal ranges and mineral licks (Geist, 1971).

13.4.6 Seasons of Use

Table 82 summarizes the rated life requisites for Stone's sheep for each month of the year.

Table 82: Monthly Rated Life Requisites for Stone's Sheep in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	LI-SH, FD
February	W	LI-SH, FD
March	W	LI-SH, FD
April	W	LI-SH, FD
May	G	LI-SH, FD
June	G	LI-SH, FD
July	G	LI-SH, FD
August	G	LI-SH, FD
September	G	LI-SH, FD
October	W	LI-SH, FD
November	W	LI-SH, FD
December	W	LI-SH, FD

Legend
W=Winter G=Growing LI=Living FD=Food SH=Security
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

13.5 Habitat Use and Ecosystem Attributes

Table 83 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 83: Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for Stone's Sheep

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	site: slope, aspect, elevation, structural stage, site disturbance soil/terrain: bedrock, terrain texture, flooding regime vegetation: % cover by layer, species list by layer, cover for each species for each layer low snow depth
Living Habitat (Security)	site: slope >100%, aspect, elevation, structural stage soil/terrain: terrain texture vegetation: % cover by layer, species list by layer, cover for each species for each layer cliffs, rugged terrain, areas of high visibility, low snow depth

13.6 Development of the Habitat Ratings

13.6.1 Rating Scheme

A 6-Class rating scheme of high (1), moderately high (2), moderate (3), low (4), very low (5), and nil (6) is employed due to the substantial level of knowledge on habitat use of Stone's sheep (RIC, 1998). The used ratings scheme is defined in Table 84.

Table 84: Habitat Capability and Suitability 6-Class Rating Scheme
(from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	1
75% - 51%	Moderately High	2
50% - 26%	Moderate	3
25% - 6%	Low	4
5% - 1%	Very Low	5
0%	Nil	6

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for Stone's sheep, as previously outlined in Table 81.

13.6.2 Provincial Benchmark

The provincial standard (best in B.C.) for the winter season for the Stone's sheep is the MUF ecosection, SWBmk subzone, within the Northern Boreal Mountains ecoprovince (RIC, 1998). The growing season benchmark is the MUF ecosection, AT subzone (RIC, 1998).

The southwestern section of the Dunedin study area is located within the MUF ecosection, which is the provincial benchmark for Stone's sheep (RIC, 1998) . The majority of the study area is located within the MUP ecosection, which has a low (25% to 6%) capability compared to the standard (RIC, 1998).

As a smaller scale reference, the Northeastern British Columbia Biophysical Overview Mapping project has assigned Stone's sheep habitat capability ratings for the ecosection/BEC variant combinations found within this region (Table 85) (Habitat Inventory Section, 1994).

Table 85. Ecosection/BEC variant combinations for Stone's Sheep
Class values for habitat capability mapping of the northeastern portion of B.C.
(Habitat Inventory Section, 1994)

Ecosection	**MUP**		**MUF**		
Variant	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**AT**
Species					
Stone's Sheep	5	5	3	1	1

Legend:
6-class rating scheme: Class 1 - high, Class 2 - moderately high, Class 3 - moderate, Class 4 - low, Class 5- very low and Class 6 - nil value.

13.6.3 Ratings Assumptions

Habitat ratings for Stone's sheep are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the Stone's sheep's seasonal requirements for feeding and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 83) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- During the growing season ecosystem units with preferred vegetation and high percent cover are given high food ratings. Grasses, sedges, forbs and willows are considered high value forage species (Seip, 1973). Sheep may forage in burned units of early shrub stages of BWBS if near to escape terrain. Structural stage 2 generally has the highest foraging values for Stone's sheep. Often, stages 3 and 3a also have moderate to high values. In general, structural stage 1 has poor foraging value as it is mainly unvegetated.
- In the winter season vegetation within the BWBS is considered inaccessible, due to restrictive snow depths. Therefore, all BWBSmw2 and BWBSwk3 units are given a rating of nil for food value in this season.
- Throughout most of the study area, suitable escape terrain does not exist for Stone's sheep. The only areas of BWBS which will be utilized are located in valley bottoms within the MUF ecosection of the study area. These areas are probably used by sheep travelling between mountains, or to water or mineral licks. Sheep will forage in units adjacent to good escape terrain.
- Security habitat consists of cliffs, rock outcroppings and bluffs, rugged terrain and steep slopes >100%. Units which provide these characteristics receive high security habitat ratings. Open habitats providing good visibility will also afford some protection, so are given low to moderate security ratings. Units in the SWB zone are given a minimum security habitat rating of 5 in the growing season due to the higher elevation providing some protection from predators. Units in the SWBmks receive a minumum security habitat rating of 4 and AT units receive a minimum security habitat rating of 3 in the growing season due to the higher elevation and greater visibility in these sites.
- In winter, security habitat is assumed to be barren, wind-swept ridges as these are the core winter range of Stone's Sheep. Therefore, all BWBS units are given a rating of nil for security habitat, except cliffs. Sheep may pass through BWBS units as they travel between winter ranges.

13.6.4 Rating Adjustment Considerations

Factors such as adjacency to escape terrain, behavioural adaptations, interspersion of habitats, location of mineral licks, and migration routes will strongly affect habitat use. Aspect and snow depth are very important factors, yet there is insufficient understanding of these factors within the Dunedin study area to build them into the species habitat-model at this time. Future information on snow conditions within the Dunedin area will help to refine the model.

Stone's sheep will generally forage within 200 m of escape terrain (D. Seip, *pers. comm.*). Units farther away than this from suitable security habitat will have proportionally less value. Habitats over approximately 500 m away from escape terrain will probably have very low habitat value.

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14.0 SPECIES - HABITAT MODEL FOR WOODLAND CARIBOU

Common Name:	**Woodland Caribou** (Northern Ecotype)
Scientific Name:	*Rangifer tarandus caribou*
Species Code:	M-RATA
B.C. Status:	Northern Ecotype is Yellow-listed; Mountain Ecotype is Blue-Listed (B.C. MOELP, 1996, B.C. CDC, 1997)
Identified Wildlife Status:	None
COSEWIC Status:	Western populations were designated as vulnerable in Canada, following a review in 1984 (COSEWIC, 1997).

14.1 Introduction

Information from past studies in northern British Columbia (Hatler, 1986; Murray, 1992; Cichowski, 1989), current research and surveys (Wood 1993, 1996; Terry and Wood, 1998; Corbould, 1993), and, where applicable, information from other areas outside of northern B.C. have been used to create this woodland caribou model. At this time, no model verification has been completed for the Dunedin area, and the species-habitat model is predicted to have low reliability.

Woodland caribou conservation has been a high profile resource management issue in British Columbia for many years primarily because of the conflict between forest harvesting and conservation of caribou habitat (Seip, 1996). Most habitat use studies have been focused on the woodland caribou populations in the southeast part of the province due to the more immediate conflicts between forest harvesting and declining populations in this area (Stevenson, 1991). However, with the increasing demands for forest products throughout the province and decreasing availability of these resources, the focus has expanded to include woodland caribou populations in the northern part of the province (Terry and Wood, 1998). The species-habitat model is a step in the process to understand the relationship between caribou habitat use and habitat suitability and capability.

14.2 Distribution

14.2.1 Provincial Range

All caribou in British Columbia belong to the woodland subspecies (*Rangifer tarandus*) (Seip and Cichowski, 1996) but they can be further classified into three different ecotypes: the mountain ecotype, the northern ecotype, and the boreal ecotype (Heard and Vagt, 1996). This division into ecotypes is based on behavioural and ecological differences (Heard and Vagt, 1996). Mountain caribou occur in the rugged mountains of southeastern B.C. and spend most of the year in alpine and subalpine habitats (Seip and Cichowski, 1996). They winter at high elevations and rely primarily on arboreal lichens for food because the deep snowpack in this region prevents them from cratering for terrestrial foods (Seip and Cichowski, 1996; Stevenson and Hatler, 1985). Northern caribou are found in the mountains of northern and western British Columbia where there is low snowfall relative to mountain caribou habitat (Bergerud, 1978, in Heard and Vagt, 1996). They generally summer in mountainous areas and winter in mature low elevation lodgepole pine or black spruce forests or in windswept alpine areas (Seip and Cichowski, 1996; Heard and Vagt, 1996). Low snow depths in these habitats allows northern caribou to crater for terrestrial lichens, which are their primary forage during the winter (Heard and Vagt, 1996; Seip and Cichowski, 1996). Boreal caribou are found in the boreal forests of northeastern B.C. where they occur in small, dispersed groups that are relatively sedentary throughout the year (Heard and Vagt, 1996). Sometimes authors lump the boreal ecotype and northern ecotype together (referenced to as the northern ecotype) (Heard and Vagt, 1996). The British Columbia population of caribou was estimated at a total of 18,000 animals in 1996 (Heard and Vagt, 1996). Of these, approximately 2,300 were mountain caribou and 16,000 were northern and boreal caribou (Heard and Vagt, 1996).

Population numbers have been estimated for the general area of the Dunedin and the adjacent watersheds. The boreal caribou population in northeastern British Columbia was estimated at approximately 725 animals in 1996. The Muskwa northern caribou herd (also known as the Mt. Dell; Crest; Toad; or MacDonald-Racing herd) is found to the immediate south of the Dunedin watershed, and its range may include some of the Dunedin study area. This herd had an estimated 1,250 animals in 1996 (Heard and Vagt, 1996; D. Heard, *pers. comm*., 1996). Caribou found in the southern portion of the Dunedin study area presumably belong to this herd. Population trends of these caribou herds are unknown (Heard and Vagt, 1996).

14.2.2 Distribution in the Study Area

On a provincial basis, the relative abundance of caribou is rated as few (1 caribou per 25 km^2 to 250 km^2) present in the northern half of the Dunedin study area and the lower half is rated as moderate (1 caribou per 3.4 km^2 to 25 km^2) relative abundance (Fish, Wildlife and Habitat Protection Department, 1994). The area immediately surrounding Stone Mountain Park has a plentiful rating of over 1 caribou per 3.4 km^2 (Fish, Wildlife and Habitat Protection Department, 1994). Expected woodland caribou occurrence within the ecoregions, ecosections, and biogeoclimatic zones of the study area is summarized in Table 86.

Table 86: Expected Woodland Caribou Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	**TAIGA PLAINS**		**NORTHERN BOREAL MOUNTAINS**			
Ecoregions	**Muskwa Plateau**		**Northern Canadian Rocky Mountains**			
Ecosections	**MUP**		**MUF**			
BEC Variants	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**SWBmks**	**AT**
Species						
Northern Caribou Ecotype	?	?	•	•	•	•
Boreal Caribou Ecotype	•	•	?	?	?	?

Legend:
• = occurs in the variant
•? = probably occurs in the variant
? = unlikely to occur in the variant
x = essentially absent

Woodland caribou occur in both ecosections found within the Dunedin study area, yet as the distinction between northern and boreal ecotypes is not always clear, it is unknown which are present in the study area. Northern caribou are probably found within the more mountainous southern portion of the study area corresponding to the MUF ecosection. However, low-lying areas that dominate the central and northern portions (corresponding to the MUP ecosection) of the study area may be occupied by the boreal ecotype. This species-habitat model concentrates on the habitat requirements of the northern ecotype of woodland caribou as this ecotype presumably predominates within the study area, and most higher value caribou habitats will be found in the MUF ecosection.

14.2.3 Elevational Range

Northern caribou are expected to occur in the BWBS zone, SWB zone and the AT zone (approx. 250 m to 2,105 m) within the study area.

14.3 Ecology and Habitat Requirements

Unlike their barren ground counterparts, woodland caribou do not form large herds but instead move in relatively smaller groups (B.C. MoELP, 1992). Northern caribou occupy large home ranges and migrate in response to seasonal habitat requirements. Generally they use high elevation forests and alpine habitat for calving, post-calving, summer, and rutting grounds and move to lowland forested areas in the winter (Fenger *et al.,* 1986). When snow conditions become prohibitive in the winter, caribou may move to windswept slopes in the alpine where terrestrial lichens will be available (Heard and Vagt, 1996).

Caribou are characterised by a horizontal migratory behaviour as they frequent traditional calving, rutting, wintering, and post-calving ranges over a seasonal cycle (Child and King, 1991). Caribou tend to show fidelity to core areas for calving (Hatler, 1986; Farnell and McDonald, 1989), for rutting (Farnell *et al*., 1991), and to seasonal ranges (Farnell and McDonald, 1989).

In Manitoba, caribou used frozen lakes for travel, escape habitat, and to crater to drinking overflow water throughout the winter (Darby and Pruitt, 1984). Terry and Wood (1998) found that in spring “other” (non-forested areas, lakes) habitats were used more extensively than their occurrence. Caribou were observed using lakes during early winter (D. Becker, M. Wood, *pers. comms.*) possibly for drinking overflow water containing dissolved minerals.

14.4 Habitat use (Life Requisites and Seasons)

Northern caribou habitat use for the study area is broken down into three seasons – growing, early winter, and late winter. Life requisites that are rated for caribou include living, feeding, reproducing, and security, as summarized in Table 87.

Table 87: Summary of Rated Life Requisites and Seasons for Northern Caribou in the Dunedin Study Area

Rated Life Requisites and Seasons	Code	Months of Use	Comments
Living during the growing season - food	LI_G_FD	April-September	- habitats with early forage production - migrate to summer range - feed in areas of late snow-melt which can either be in the alpine or in low elevation pine forests - rutting generally occurs in the alpine
Living during the early winter season - food	LI_EW_FD	October-December	- regions of low snow cover and abundant terrestrial lichens - low-elevation forests
Living during the late winter season - food	LI_LW_FD	January-March	- either wind-swept alpine ridges or lower elevation pine - lichen forests (dependent on snow accumulations)
Reproducing by birthing - food Reproducing by birthing - security	RB_FD RB_SH	late May-mid June	- give birth on secluded alpine ridges, at treeline, or in high elevation coniferous stands.

Ecosystem units were not rated for security during the growing, early winter and late winter seasons as security habitat is not well defined for caribou. Rated life requisites are described in detail below. Additional information on rutting and thermal habitat requirements is included, although these requisites have not been rated.

14.4.1 Living

The living life requisite for northern caribou is satisfied by the presence of suitable feeding, reproducing and security habitat, which are described in detail below.

14.4.2 Feeding

Information on general feeding and habitat use over the winter season is summarized in the following section. This information is then broken into early winter, and late winter seasons. Growing season habitat use is also discussed.

General Winter Habitat Use and Lichen Ecology

Bergerud (1978) found northern caribou depend on ground lichens for winter foraging rather than on arboreal lichens, which constitute only a very minor component of the winter diet. Ground lichens make up over 70% of the winter diet of northern caribou in the Yukon and northern B.C., with *Cladina* spp. and *Cladonia* spp. predominating in the diet (Farnell and McDonald, 1990; Farnell and McDonald, 1989; Farnell *et al.,* 1991; Stevenson and Hatler, 1985). Horsetails, grasses, and sedges (primarily *Carex* spp.) can also be components of the winter diet (Farnell and McDonald, 1990).

Terrestrial lichens are very slow growing and are most abundant in late successional forests (Cichowski, 1996). Disturbances such as logging drastically alter lichen populations, which can require 50 to 100 years to regenerate (Hale, 1983 and Rowe, 1984 in Cichowski, 1996). Cichowski (1989) found caribou selected mature stands with a combination of abundant terrestrial lichens (Dry Lichen/Lichen Moss, Lichen Moss understories) and low productivity (low and poor forest cover types). Because terrestrial lichens are poor competitors against vascular plants, they are most abundant on open, nutrient poor sites (Hale, 1983 and Rowe, 1984 in Cichowski, 1996). Undisturbed areas within the winter range are important for maintaining winter forage availability (Cichowski, 1989).

Terrestrial lichens that are usually destroyed by fires but recolonize disturbed sites become abundant in mid-aged to mature stands. Xeric growing sites support abundant terrestrial lichens for hundreds of years. However, on more productive sites, terrestrial lichens may be abundant in mid-aged stands but are replaced by mosses in older stands and thus require periodic disturbance to be perpetuated. Very productive sites are usually dominated by vascular plants and never produce substantial amounts of terrestrial lichens (Seip, 1996).

For northern caribou, some of the primary early winter habitats are mature lodgepole pine or pine/spruce forests with abundant terrestrial lichens (Heard and Vagt, 1996; Wood, 1996). Wood (1993) found that northern caribou in the Omineca Mountains foraged on terrestrial lichens in both lowland lodgepole pine flats and windswept alpine slopes and on arboreal lichens in upper elevation Engelmann Spruce Subalpine fir forests. Cichowski (1989) found that in pine forests, northern caribou feed predominantly by cratering for terrestrial lichens, and cratering sites were selected on the basis of terrestrial lichen abundance. Arboreal lichens were also used but appear to be less important than terrestrial lichens in the diet. Arboreal lichen use is greater during late winter when snow conditions are less favorable for cratering (Cichowski, 1989).

Another habitat used during the winter is alpine slopes with low snow accumulations. Some northern caribou populations regularly winter in alpine habitats. More commonly, the alpine is used by a small proportion of caribou or by many caribou for a short time. Northern caribou often move to the alpine when snow conditions below tree line restrict their ability to move around or to forage (Terry and Wood, 1998; Hatler, 1986).

Telemetry locations from the Graham River northern caribou herd indicated that the caribou spent a significant portion of at least late winter in the alpine tundra or subalpine forest. Northern caribou in this area were speculated to spend the majority of the year in alpine or subalpine habitats (Murray, 1992).

Early Winter Season

Northern caribou generally winter in low-elevation, mature pine or pine/spruce stands (Hatler, 1986). Open areas below timberline including muskegs and shrub or herb meadows are also used in winters of light snowfall (Hatler, 1986).

Snow depths exceeding 50 cm to 60 cm are limiting to single caribou cratering for lichens, and snow depths of 80 cm to 90 cm are considered limiting to cratering by groups of caribou (Russell and Martell, 1984). Beyond these snow depths or when hard-packed crusts develop, caribou are unable to locate and dig down to lichens (Russell and Martell, 1984). When snow depths become limiting, northern caribou will move from early winter ranges to late winter ranges. In winters of low snowfall, northern caribou will often remain in their early winter ranges (primarily lowland, coniferous forests) for the entire winter (Hatler, 1986).

Late Winter Season

During the late winter season, unfavourable snow conditions may force northern caribou to concentrate in alpine habitat (Hatler, 1986). They will move to high wind-swept ridges where there is access to terrestrial lichens when snow-depths preclude feeding in forests (Stevenson and Hatler, 1985). In studies that have covered multiple years, northern caribou have been found to use alpine habitat in winter only when snow depths preclude the use of lower elevation forests (Terry and Wood, 1998; Cichowski, 1996; Wood, 1996). Terry and Wood (1998) and Hatler (1986) found the use of alpine habitats was the result of heavy snow accumulations forcing the animals to move to higher elevations. Such use of alpine by northern caribou indicates a stressed situation occurring in severe winters and should not be interpreted as a preferred winter habitat (Hatler, 1986).

Surveys completed on the east side of Williston reservoir showed high use of alpine areas by northern caribou in the late winter (D. Becker, pers. comm.). Surveys on the east side of Williston Reservoir in the Chase Mountain and Wolverine Ranges also showed high use of the alpine in the late winter (Corbould, 1993).

Growing Season

Spring habitats are often found at low-elevations, with caribou moving to alpine or subalpine ranges in summer, although use of lower elevations also occurs (Stevenson and Hatler, 1985). During the spring, northern caribou occupy the lowest elevations of the year (Hatler, 1986). Wood (1996) found northern caribou primarily in low elevation lodgepole pine and pine/spruce forests in the spring (April/May). At this time of year, northern caribou also forage in meadows and younger seral stands of pine and pine/aspen stands (Wood, 1996).

Summer ranges for northern caribou are typically alpine or subalpine, although some animals in some populations use low elevations (Stevenson, 1991). Little information has been collected on growing season diets as these are not generally considered limiting. Northern caribou will forage on a diversity of grasses, sedges, forbs, browse, and lichens. Throughout the summer in the Kluane Range, Yukon Territory, northern caribou fed disproportionately in birch-sedge meadows, sedge meadow communities, and other communities with high sedge components in the subalpine and alpine (Oosenburg and Theberge, 1980). Sedge was considered to be the most important forage in determining summer habitat selection (Oosenburg and Theberge, 1980). Willows and other shrubs were also important components of the summer diet (Oosenburg and Theberge, 1980).

Throughout the summer and early fall, northern caribou were found to prefer flat to rolling terrain with slopes less than 20° and northern aspects in the Kluane Range, Northwest Territories (Oosenburg and Theberge, 1980). Use of these sites may have reflected their hygric nature and consequent predominance of sedges (Oosenburg and Theberge, 1980). Commonly used landforms during the summer season included ridges, plateaus, and stream bottoms (Oosenburg and Theberge, 1980).

14.4.3 Reproduction

Most calving occurs during late May through mid-June with the peak of calving around the first week of June (Hatler, 1986; Wood, 1996). Recruitment (the number of individuals entering the population at 1 year of age) is low (Rock, 1992). Caribou do not twin; therefore potential population growth is slow.

During the calving season, northern caribou move to areas that "minimize risks from predation either by using escape terrain with good visibility such as steep, isolated rock outcrops higher than the usual areas travelled by terrestrial predators or by dispersing widely over shrubby vegetation that affords concealment and lowered probability of detection" (Fenger *et al.,* 1986). Calving sites are usually on secluded alpine ridges, tree line, or in high elevation coniferous stands. In late May/early June, female caribou forgo forage quality at lower elevations to calve high in the Itcha and Ilgachuz Mountains in west-central B.C. (Cichowski, 1989). In north central B.C., northern caribou were found to calve in upper elevation balsam/spruce forests, in rocky outcrops at tree line, or in alpine/subalpine areas (Wood, 1996). In the central Yukon, northern caribou calved in alpine habitats in a widely dispersed pattern (Farnell *et al*., 1991).

Woodland caribou often show fidelity to specific areas for calving (Hatler 1986; Farnell and McDonald 1989; Farnell *et al.,* 1991). This use of traditional calving grounds and the highly dispersed pattern employed by woodland caribou is thought to be an anti-predator tactic of female caribou to reduce the vulnerability of calves and to make use of previously successful sites (Bergerud *et al.,* 1984, Seip, 1992). By calving at high elevations, female caribou space themselves away from predators such as wolves (*Canis lupus*). For woodland caribou, undisturbed mountainous habitat is important for calving success and early calf survival of woodland caribou (Bergerud *et al*., 1984).

14.4.4 Security Habitat

Security cover is most often mentioned in conjunction with calving sites with dispersion being as important a factor as security cover. Security habitat during the calving season consists of either escape terrain combined with good visibility or shrubby vegetation providing hiding cover (Fenger *et al.,* 1986). High elevations also afford some protection from wolves, which generally use valleys as travel routes (Bergerud and Elliot, 1986).

A spatial separation between caribou and moose, which generally occupy lower elevations, forces predators to search large areas, reducing their capture success (Bergerud *et al.*, 1984). More recently, however, relatively high numbers of moose exist because of the conversion of mature forested habitats to early stage habitats (logging) and the cumulative effects of milder winters over the 1980s on the increased survival of moose. Inflated numbers of early seral stage species tends to support increased numbers of predators such as wolves and bears (Seip, 1992).

In winter, large contiguous patches of unfragmented habitat may provide security cover since the preferred stands for pine-lichen tend not to have understory characteristics useful for security cover (small trees, shrubs, etc.). Habitats that offer good visibility for avoiding predators, such as the alpine, also afford some security during the winter. Predation is thought to be the major limiting factor for caribou, particularly in areas where the amount of usable habitat has been reduced by logging, fires, or fragmentation. The use of large home ranges allows caribou to select habitats offering acceptable combinations of snow conditions and food availability, select habitats that have given them an advantage over predators, and reduce their vulnerability to predators by dispersing themselves widely (Stevenson, 1991).

Predators clearly interact in an additive or compensatory way with other regulatory factors such as hunting mortality, climatic extremes, and food limitations in their degree of influence on caribou populations (Rock, 1992). In Saskatchewan, Rock (1992) suggests habitat selection is probably related more to predation considerations year-round and to thermal cover/insect harassment factors during the summer than it is to any of the food requisites. If food does become a limiting factor, it is generally during late winter when unfavourable snow conditions force caribou out of lowland habitats onto upland sites where more terrestrial lichen species may be available. Historically it would appear that late winter habitat, although important, was over-emphasised at the expense of other considerations such as predation (Rock, 1992).

14.4.5 Rutting

The rut generally occurs between late-September and mid-October (Fenger *et al.,* 1986). Alpine habitats appear to be preferred during the rutting period. The Klaza caribou herd in the Yukon moved to form large aggregations on rutting ranges on north aspect alpine areas (Farnell *et al.,* 1991). Rutting ranges were also found in the alpine by numerous authors including Farnell and McDonald (1990), Fenger *et al*. (1986), and Terry and Wood (1998). Rutting generally occurs on “gently sloping or rolling terrain with low vegetation where herd members are easily visible to each other” (Fenger *et al.,* 1986).

14.4.6 Thermal Habitat

Traditionally thermal cover has been an important consideration for the over-winter survival of large ungulates. For woodland caribou, however, the summer period would appear to be the most critical in terms of thermal cover requirements and tends to be overlooked. Alpine habitats provide cooler temperatures during periods of hot weather.

Insect harassment has been suggested as one of the reasons that caribou move to alpine habitats during part of the summer (M. Wood, pers. comm.). Cooler weather and constant breezes provide relief from insects. Farnell and McDonald (1990) found that caribou will often move to patches of snow, glaciers, and windy ridges that act as ‘relief habitat’ to escape harassment by insects and/or heat stress.

14.4.7 Seasons of Use

Table 88 summarizes the rated life requisites for northern caribou for each month of the year.

Table 88: Monthly Rated Life Requisites for Northern Caribou in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	LW	LI-FD
February	LW	LI-FD
March	LW	LI-FD
April	G	LI-FD
May	G	LI-FD, RB-SH, FD
June	G	LI-FD, RB-SH, FD
July	G	LI-FD
August	G	LI-FD
September	G	LI-FD
October	EW	LI-FD
November	EW	LI-FD
December	EW	LI-FD

Legend
LW=Late Winter EW=Early Winter G=Growing LI=Living FD=Food SH=Security RB=Reproducing (birthing)
*Seasons modified per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

14.5 Habitat Use and Ecosystem Attributes

Table 89 outlines how each rated life requisite relates to specific ecosystem attributes.

Table 89: Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for Northern Caribou

Life Requisite	Ecosystem Attribute
Living Habitat (Feeding)	site: slope, aspect, elevation, structural stage, site disturbance soil/terrain: bedrock, terrain texture, flooding regime vegetation: % cover by layer, species list by layer, cover for each species for each layer, terrestrial lichen biomass
Reproducing (Feeding)	site: slope, aspect, elevation, structural stage, site disturbance soil/terrain: bedrock, terrain texture, flooding regime vegetation: % cover by layer, species list by layer, cover for each species for each layer
Reproducing (Security)	site: slope, aspect, elevation, structural stage soil/terrain: terrain texture vegetation: % cover by layer, species list by layer, cover for each species for each layer tree species, dbh, height, CWD

14.6 Development of the Habitat Ratings

14.6.1 Rating Scheme

A 6-Class rating scheme of high (1), moderately high (2), moderate (3), low (4), very low (5), and nil (6) is employed due to the substantial level of knowledge on habitat use of northern caribou (RIC, 1998). The used ratings scheme is defined in Table 90.

Table 90: Habitat Capability and Suitability 6-Class Rating Scheme
(from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	1
75% - 51%	Moderately High	2
50% - 26%	Moderate	3
25% - 6%	Low	4
5% - 1%	Very Low	5
0%	Nil	6

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for the specific life requisites and seasons rated for northern caribou, as previously outlined in Table 87.

14.6.2 Provincial Benchmark

The provincial standard (best in B.C.) for the winter season for the northern caribou is the STP ecosection, SWBun and AT subzones (within the Central Interior ecoprovince) and the provincial standard for the growing season is the STP ecosection, AT subzone. (RIC, 1998).

The southwestern section of the Dunedin study area is located within the MUF ecosection, which has a high (100% to 76%) capability compared to the standard (RIC, 1998). The majority of the study area is located within the MUP ecosection, which has a moderately high (75% to 51%) capability compared to the standard (RIC, 1998). The Dunedin study area is therefore expected to have fairly high capability for northern caribou.

As a smaller scale reference, the Northeastern British Columbia Biophysical Overview Mapping project has assigned northern caribou habitat capability ratings for the ecosection/BEC variant combinations found within this region (Table 91) (Habitat Inventory Section, 1994).

Table 91: Ecosection/BEC Variant Combinations for Northern Caribou Class Values for Habitat Capability Mapping of the Northeastern Portion of B.C.
(Habitat Inventory Section, 1994)

Ecosection	**MUP**		**MUF**		
Variant	**BWBSmw2**	**BWBSwk3**	**BWBSmw2**	**SWBmk**	**AT**
Species					
Northern Caribou	3	3	2	2	1

Legend:
6-class rating scheme: Class 1 - high, Class 2 - moderately high, Class 3 - moderate, Class 4 - low, Class 5- very low and Class 6 - nil value.

14.6.3 Ratings Assumptions

Habitat ratings for the northern ecotype of woodland caribou are presented in Appendix 5. Each combination of ecosystem unit and structural stage was individually assessed for its ability to meet the northern caribou's seasonal requirements for feeding and security. The expanded legend and field data were used to determine if these combinations provided the necessary ecosystem attributes (as outlined in Table 89) to meet these requirements. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- During the growing season, ecosystem units with preferred vegetation and high percent cover are given high food ratings. Wet units with a predominance of sedge and horsetails receive high food ratings in the growing season.
- Northern caribou forage at lower elevations in the spring, and move to alpine and subalpine ranges in the summer. Higher elevation units in the AT, SWBmk, and SWBmks have greater value for foraging in the summer and fall due to the delayed phenology of these sites. Structural stages 2 and 3 generally have the highest value for foraging at upper elevations of the SWB and AT. In general, structural stage 1 has poor foraging value as it is mainly unvegetated. Caribou will forage more extensively in younger structural stages during the growing season. Therefore, in addition to older forested units, those units in younger structural stages (stage 4 to 5) will often have moderate growing season values.
- During the early and late winter seasons, feeding habitat is largely rated on the presence and abundance of terrestrial lichens, as this is the predominant winter forage. Units are also rated on the perceived accessibility of these sites due to snow depth. This becomes a limiting factor mainly in the late winter season. In a winter with non-restrictive snow conditions, food ratings over the entire winter will be the same as those of the early winter season.
- This model assumes all habitats are accessible to northern caribou in the early winter season as they can tolerate fairly deep snow depths. Therefore, food ratings are assigned on the basis of presence and abundance of winter forage species. In early winter, caribou feed in areas of high lichen density; generally open, dry forests, bogs, and also windswept ridges. They are usually found in forested habitats, primarily in lower elevation pine and/or spruce dominated forests, during this time period. These forest types therefore receive moderate to high food ratings.
- Units with poor nutrient regimes often provide the most lichens. In generaly, xeric, poor sites provide abundant lichens so receive high ratings in the winter seasons. Wet sites which provide poor lichen abundance receive low ratings throughout the winter. Units with abundant sedges, horsetails or grasses can have some foraging value, and are given low ratings in the early winter, as caribou may forage in these units under low snow conditions.
- Lichen production is greatest in later successional structural stages, therefore stages 6 and 7 generally receive the highest feeding values during the early winter. Younger forests (stage 4 and 5) generally do not support lichen growth and are therefore given low foraging ratings in this season. Stagnated units in stages stage 3b or 4 may also support lichen growth, and these units receive high ratings if lichens are abundant. Stage 2 or 3 units at high elevations may also provide good lichen growth. Structural stage 1 generally has very low or nil foraging value as it is mainly unvegetated.

- In late winter, feeding areas are determined by presence and availability of lichens. Late winter snow depths in an average winter are assumed to force caribou onto windswept ridges where forage is available. As windswept ridges are probably very site specific, this make it difficult to assign ratings. All units in the SWBmks and AT were assumed accessible in the late winter, and feeding values were assigned based on the vegetation present. These ratings will be too high if these areas do not blow free of snow. Late winter ratings for these units are generally higher than their early winter ratings, as these units are probably the only ones accessible in late winter, and so will be of more value. The SC unit in the SWBmks has large amounts of lichen and is probably one of the best units for foraging in the late winter. Food in lower elevation forests is assumed to be mainly inaccessible in late winter due to deep snow depths. Therefore most BWBSmw2, BWBSwk3, and SWBmks units are given ratings of nil or low for food value in the late winter. Units in these subzones with abundant lichens are rated slightly higher as some lichens may be available.
- Open spruce/pine forest (LL-02) has high foraging value in the BWBSmw2 in early winter as this unit has significant lichen ground cover. This unit will retain some value in the late winter season, although lichens may become unavailable due to deep snow. Black spruce bogs in the BWBSmw2 (BS/08) have ground lichens present in the older units (stage 3b) and therefore receive high foraging value in the early winter season. In late winter these sites may be inaccessible due to snow depths and therefore receive lower ratings. Dry SC units in the SWBmk provide high terrestrial lichen biomass and are rated very highly in the early winter season and moderately high in the late winter season.
- Security habitat during the calving season consists of either escape terrain combined with good visibility or shrubby vegetation providing concealment (Fenger *et al.,* 1986). High elevations also afford some protection from wolves, which generally use valleys as travel routes (Bergerud and Elliot, 1986). Units in the SWB zone are given a minimum security habitat rating of 5 in the reproducing season due to the higher elevation of these units providing some protection from predators. Units in the SWBmks and AT receive a minimum security habitat rating of 3 in the reproducing season due to the higher elevation and greater visibility of these areas. Structural stages 1 and 2 should provide good security habitat due to the greater visibility in these units. Stage 3 should provide good concealment for birthing, as will some higher elevation forests with high shrub cover. In general, high values for security habitat for birthing are given to units providing high elevations with either high visibility, or dense shrub cover.

Although this species account focuses on the habitat requirements of the northern ecotype, habitat ratings for the BWBS should also be generally applicable to the boreal ecotype of caribou that may occupy the MUP ecosection within the study area. Habitat ratings may need to be upgraded or otherwise adjusted based on further review, as by applying the ratings developed here to the boreal ecotype it is possible some of the units may be undervalued, as boreal and northern caribou have some ecological differences in habitat use.

Boreal caribou in northeastern Alberta were found to concentrate feeding in forested, raised bogs throughout the winter (Bradshaw *et al*., 1995). The high peatland coverage in these areas provided a xeric substrate for increased production of terrestrial lichens (Bradshaw *et al*., 1995). These caribou may use denser forest stands when there are heavy snow depths (late winter), especially when snow is crusted (Bradshaw *et al*., 1995). Snow crusts were found to be thinner and less solid in denser stands than in open areas, allowing for easier movements and foraging (Bradshaw *et al*., 1995).

14.6.4 Rating Adjustment Considerations

There is a concern that fragmenting caribou habitat into a patchwork of mature and early seral forests will bring caribou and early seral ungulate species (e.g., moose) into close proximity, increase predator populations (e.g., wolves) in the area, and thereby lead to an increase in predation on caribou (Seip, 1996). Consequently, maintaining large, contiguous tracts of old forest is generally seen as preferable to maintaining fragmented patches of mature forest interspersed with clearcuts (Seip, 1996). Suitable foraging habitat should be maintained in large unfragmented patches to keep the caribou spatially separated from early seral habitats where they would encounter increased exposure to moose and wolves (Seip, 1996). Fragmentation will therefore reduce the value of ecosystem units. Fragmentation is an important part of caribou habitat suitability and can only be determined by looking at the landscape level.

Snowpack is a very important factor determining winter habitat use, yet there is insufficient understanding of this factor within the Dunedin study area to build it further into the species-habitat model at this time. Future information on snow conditions within the Dunedin area will help to refine the model.

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15.0 APPENDICES

Appendix 1: Common and Scientific Plant Species Names

Common Name	Scientific Name
Alaska paper birch	*Betula neoalaskana*
Alaska willow	*Salix alaxensis*
Alaska willow	*Salix alaxensis var. longistylis*
Aleutian mugwort	*Artemisia tilesii*
alpine arnica	*Arnica angustifolia*
alpine bearberry	*Arctostaphylos alpina var. alpina*
alpine bearberry	*Arctostaphylos alpina var. rubra*
alpine bistort	*Polygonum viviparum*
alpine bluegrass	*Poa alpina*
alpine clubmoss	*Lycopodium alpinum*
alpine hedysarum	*Hedysarum alpinum*
alpine sweetgrass	*Hierochloe alpina*
alpine timothy	*Phleum alpinum*
Altai fescue	*Festuca altaica*
American milk-vetch	*Astragalus americanus*
American speedwell	*Veronica beccabunga*
American vetch	*Vicia americana*
apetalous campion	*Silene uralensis ssp. attenuata*
apple pelt	*Peltigera malacea*
arctic aster	*Aster sibiricus*
arctic bluegrass	*Poa arctica*
arctic dock	*Rumex arcticus*
arctic lupine	*Lupinus arcticus*
arctic willow	*Salix arctica*
arctic wintergreen	*Pyrola grandiflora*
arctic woodrush	*Luzula arctica*
arrow-leaved coltsfoot	*Petasites sagittatus*
arrow-leaved groundsel	*Senecio triangularis*
Athabasca willow	*Salix athabascensis*
awned haircap moss	*Polytrichum piliferum*
awned sedge	*Carex atherodes*
balsam poplar	*Populus balsamifera ssp. balsamifera*
balsam willow	*Salix pyrifolia*
baneberry	*Actaea rubra*
Barratt's willow	*Salix barrattiana*
bastard toad-flax	*Geocaulon lividum*
beaked sedge	*Carex utriculata*
Bebb's willow	*Salix bebbiana*
Bellard's kobresia	*Kobresia myosuroides*
Bering chickweed	*Cerastium beeringianum*
bilberry willow	*Salix myrtillifolia*
bilberry willow	*Salix myrtillifolia var. cordata*
bitter fleabane	*Erigeron acris*
black alpine sedge	*Carex nigricans*

Common Name	Scientific Name
black gooseberry	*Ribes lacustre*
black huckleberry	*Vaccinium membranaceum*
black spruce	*Picea mariana*
black-foot cladonia	*Cladonia gracilis ssp. turbinata*
blackish locoweed	*Oxytropis nigrescens*
black-tipped groundsel	*Senecio lugens*
bluegrass	*Poa sp.*
bluejoint	*Calamagrostis canadensis*
bog blueberry	*Vaccinium uliginosum*
bog bluegrass	*Poa leptocoma*
bog cranberry	*Oxycoccus oxycoccos*
bog haircap moss	*Polytrichum strictum*
bog willow	*Salix pedicellaris*
bog-rosemary	*Andromeda polifolia*
boreal sandwort	*Minuartia rubella*
bracted lousewort	*Pedicularis bracteosa*
broad-leaved willowherb	*Epilobium latifolium*
brome	*Bromus sp.*
bronze sedge	*Carex aenea*
broom moss	*Dicranum scoparium*
brown pixie cup	*Cladonia pyxidata*
brownish sedge	*Carex brunnescens*
buckbean	*Menyanthes trifoliata*
bunchberry	*Cornus canadensis*
Canada goldenrod	*Solidago canadensis*
capitate lousewort	*Pedicularis capitata*
Chamisso's cotton-grass	*Eriophorum chamissonis*
clasping twistedstalk	*Streptopus amplexifolius*
cloudberry	*Rubus chamaemorus*
coastal leafy moss	*Plagiomnium insigne*
common brown sphagnum	*Sphagnum fuscum*
common false asphodel	*Tofieldia pusilla*
common green sphagnum	*Sphagnum girgensohnii*
common horsetail	*Equisetum arvense*
common juniper	*Juniperus communis*
common leafy moss	*Plagiomnium medium*
common mitrewort	*Mitella nuda*
common red sphagnum	*Sphagnum capillifolium*
common touch-me-not	*Impatiens noli-tangere*
compact selaginella	*Selaginella densa*
confused woodrush	*Luzula confusa*
cordate-leaved saxifrage	*Saxifraga nelsoniana*
cordroot sedge	*Carex chordorrhiza*
cotton-grass	*Eriophorum sp.*
cow-parsnip	*Heracleum lanatum*
creamy peavine	*Lathyrus ochroleucus*
crowberry	*Empetrum nigrum*

Common Name	Scientific Name
crumpled-leaf moss	*Rhytidium rugosum*
curled dock	*Rumex crispus*
curly heron's-bill moss	*Dicranum fuscescens*
devil's club	*Oplopanax horridus*
diverse-leaved cinquefoil	*Potentilla diversifolia*
diverse-leaved cinquefoil	*Potentilla diversifolia var. diversifolia*
Douglas' water-hemlock	*Cicuta douglasii*
Drummond's leafy moss	*Plagiomnium drummondii*
Drummond's willow	*Salix drummondiana*
dwarf blueberry	*Vaccinium caespitosum*
dwarf rattlesnake orchid	*Goodyera repens*
dwarf scouring-rush	*Equisetum scirpoides*
enchanter's-nightshade	*Circaea alpina*
entire-leaved daisy	*Leucanthemum integrifolium*
entire-leaved mountain-avens	*Dryas integrifolia*
fairyslipper	*Calypso bulbosa*
Falkland Island sedge	*Carex macloviana*
false-polytrichum	*Timmia austriaca*
Farr's willow	*Salix farriae*
felt pelt	*Peltigera ponojensis*
few-finger lichen	*Dactylina arctica*
few-flowered meadowrue	*Thalictrum sparsiflorum*
few-flowered sedge	*Carex pauciflora*
field chickweed	*Cerastium arvense*
fire moss	*Ceratodon purpureus*
fireweed	*Epilobium angustifolium*
fleabane	*Erigeron sp.*
four-angled mountain-heather	*Cassiope tetragona*
four-parted gentian	*Gentianella propinqua*
fragile fern	*Cystopteris fragilis*
fragrant wood fern	*Dryopteris fragrans*
freckle pelt	*Peltigera aphthosa*
fringed brome	*Bromus ciliatus*
fringed grass-of-Parnassus	*Parnassia fimbriata*
fuzzy-spiked wildrye	*Leymus innovatus*
glaucous gentian	*Gentiana glauca*
glaucous-leaved honeysuckle	*Lonicera dioica*
glow moss	*Aulacomnium palustre*
golden fuzzy fen moss	*Tomentypnum nitens*
golden ragged moss	*Brachythecium salebrosum*
great northern aster	*Aster modestus*
green alder	*Alnus crispa ssp. crispa*
green paw	*Nephroma arcticum*
green sorrel	*Rumex acetosa*
green wintergreen	*Pyrola chlorantha*
grey reindeer lichen	*Cladina rangiferina*
grey sedge	*Carex canescens*

Common Name	Scientific Name
grey-leaved willow	*Salix glauca*
ground-cedar	*Lycopodium complanatum*
hair bentgrass	*Agrostis scabra*
hawkweed-leaved saxifrage	*Saxifraga hieraciifolia*
heart-leaved arnica	*Arnica cordifolia*
heart-leaved twayblade	*Listera cordata*
highbush-cranberry	*Viburnum edule*
hoary rock moss	*Racomitrium lanuginosum*
hooded ladies' tresses	*Spiranthes romanzoffiana*
horn cladonia	*Cladonia cornuta*
icelandmoss	*Cetraria ericetorum*
icelandmoss	*Cetraria islandica ssp. islandica*
Indian hellebore	*Veratrum viride*
juniper haircap moss	*Polytrichum juniperinum*
Kentucky bluegrass	*Poa pratensis*
kidney-leaved violet	*Viola renifolia*
kinnikinnick	*Arctostaphylos uva-ursi*
knight’s plume	*Ptilium crista-castrensis*
Labrador lousewort	*Pedicularis labradorica*
Labrador tea	*Ledum groenlandicum*
lady fern	*Athyrium filix-femina*
Lapland rosebay	*Rhododendron lapponicum*
large round-leaved rein orchid	*Platanthera orbiculata*
large-leaved avens	*Geum macrophyllum*
leatherleaf	*Chamaedaphne calyculata*
lesser panicled sedge	*Carex diandra*
limestone sunshine	*Vulpicida tilesii*
Lindley's aster	*Aster ciliolatus*
lingonberry	*Vaccinium vitis-idaea*
little buttercup	*Ranunculus uncinatus*
little meadow-foxtail	*Alopecurus aequalis*
lodgepole pine	*Pinus contorta var. latifolia*
long-bracted frog orchid	*Coeloglossum viride ssp. bracteatum*
long-stalked starwort	*Stellaria longipes*
long-styled sedge	*Carex stylosa*
lousewort	*Pedicularis sp.*
low birch	*Betula pumila*
MacCalla's willow	*Salix maccalliana*
Mackenzie's willow	*Salix prolixa*
marsh cinquefoil	*Potentilla palustris*
marsh horsetail	*Equisetum palustre*
marsh valerian	*Valeriana dioica*
marsh violet	*Viola palustris*
marsh yellow cress	*Rorippa palustris*
Maydell's locoweed	*Oxytropis maydelliana*
meadow horsetail	*Equisetum pratense*
meadow willow	*Salix petiolaris*

Common Name	Scientific Name
meadowrue	*Thalictrum sp.*
moschatel	*Adoxa moschatellina*
moss campion	*Silene acaulis*
mountain alder	*Alnus tenuifolia*
mountain death-camas	*Zigadenus elegans*
mountain forget-me-not	*Myosotis alpestris*
mountain harebell	*Campanula lasiocarpa*
mountain monkshood	*Aconitum delphiniifolium*
mountain sagewort	*Artemisia norvegica*
mountain willow	*Salix pseudomonticola*
nagoonberry	*Rubus arcticus*
nagoonberry	*Rubus arcticus*
narcissus anemone	*Anemone narcissiflora*
narrow-flowered bluegrass	*Poa stenantha*
narrow-leaved bur-reed	*Sparganium angustifolium*
narrow-leaved cotton-grass	*Eriophorum angustifolium*
netted willow	*Salix reticulata ssp. reticulata*
nodding wood-reed	*Cinna latifolia*
northern anemone	*Anemone parviflora*
northern bedstraw	*Galium boreale*
northern bush willow	*Salix arbusculoides*
northern goldenrod	*Solidago multiradiata*
northern gooseberry	*Ribes oxyacanthoides*
northern grass-of-Parnassus	*Parnassia palustris*
northern Labrador tea	*Ledum palustre ssp. decumbens*
northwestern twayblade	*Listera caurina*
Norwegian cinquefoil	*Potentilla norvegica*
oak fern	*Gymnocarpium dryopteris*
one-flowered cinquefoil	*Potentilla uniflora*
one-leaved rein orchid	*Platanthera obtusata*
one-sided wintergreen	*Orthilia secunda*
paintbrush	*Castilleja sp.*
palmate-leaved coltsfoot	*Petasites frigidus var. palmatus*
paper birch	*Betula papyrifera*
partridgefoot	*Luetkea pectinata*
pelt lichens	*Peltigera sp.*
pinegrass	*Calamagrostis rubescens*
pink wintergreen	*Pyrola asarifolia*
plated rocktripe	*Umbilicaria muehlenbergii*
polar willow	*Salix polaris*
polargrass	*Arctagrostis latifolia*
polargrass	*Arctagrostis latifolia var. arundinacea*
poor sedge	*Carex magellanica*
prickly rose	*Rosa acicularis*
prince's-pine	*Chimaphila umbellata*
purple mountain saxifrage	*Saxifraga oppositifolia*
purple-leaved willowherb	*Epilobium ciliatum ssp. ciliatum*

Common Name	Scientific Name
pussy willow	*Salix discolor*
ragged snow	*Flavocetraria nivalis*
Raup's willow	*Salix raupii*
red pixie cup	*Cladonia borealis*
red raspberry	*Rubus idaeus*
red swamp currant	*Ribes triste*
red-osier dogwood	*Cornus stolonifera*
red-stemmed feathermoss	*Pleurozium schreberi*
ribbed cladonia	*Cladonia cariosa*
rock worm lichen	*Thamnolia vermicularis*
Rocky Mountain fescue	*Festuca saximontana*
round-leaved sundew	*Drosera rotundifolia*
running clubmoss	*Lycopodium clavatum*
russet sedge	*Carex saxatilis*
sandbar willow	*Salix exigua*
saxifrage	*Saxifraga sp.*
scarlet paintbrush	*Castilleja miniata*
scheuchzeria	*Scheuchzeria palustris*
Scouler's willow	*Salix scouleriana*
scouring-rush	*Equisetum hyemale*
scrub birch	*Betula glandulosa*
sedge	*Carex sp.*
sheathed cotton-grass	*Eriophorum vaginatum*
sheathed sedge	*Carex vaginata*
sheep sorrel	*Rumex acetosella*
short-anthered cotton-grass	*Eriophorum brachyantherum*
short-fruited willow	*Salix brachycarpa*
short-leaved sedge	*Carex misandra*
showy locoweed	*Oxytropis splendens*
shrubby cinquefoil	*Potentilla fruticosa*
sickle moss	*Drepanocladus uncinatus*
sidewalk moss	*Tortula ruralis*
simple kobresia	*Kobresia simpliciuscula*
single delight	*Moneses uniflora*
single-spike sedge	*Carex scirpoidea*
single-spike sedge	*Carex scirpoidea var. scirpoidea*
Sitka alder	*Alnus crispa ssp. sinuata*
skunk currant	*Ribes glandulosum*
slender cotton-grass	*Eriophorum gracile*
slender wheatgrass	*Elymus trachycaulus*
slimstem reedgrass	*Calamagrostis stricta*
small bedstraw	*Galium trifidum*
small-awned sedge	*Carex microchaeta*
small-flowered bulrush	*Scirpus microcarpus*
small-flowered lousewort	*Pedicularis parviflora*
small-flowered woodrush	*Luzula parviflora*
sockeye psora	*Psora decipiens*

Common Name	Scientific Name
soft-leaved sedge	*Carex disperma*
soopolallie	*Shepherdia canadensis*
sparse-leaved sedge	*Carex tenuiflora*
spike trisetum	*Trisetum spicatum*
spiked woodrush	*Luzula spicata*
spike-like goldenrod	*Solidago spathulata*
spikenard sedge	*Carex nardina*
spotted saxifrage	*Saxifraga bronchialis*
spraypaint	*Icmadophila ericetorum*
spreading arctic sedge	*Carex supina*
step moss	*Hylocomium splendens*
Steven's spirea	*Spiraea stevenii*
stiff clubmoss	*Lycopodium annotinum*
stinging nettle	*Urtica dioica*
stoloniferous saxifrage	*Saxifraga flagellaris*
stream violet	*Viola glabella*
subalpine daisy	*Erigeron peregrinus ssp. callianthemus*
subalpine fir	*Abies lasiocarpa*
Sudeten lousewort	*Pedicularis sudetica*
sulphur cladonia	*Cladonia sulphurina*
swamp horsetail	*Equisetum fluviatile*
sweet coltsfoot	*Petasites frigidus var. frigidus*
sweet gale	*Myrica gale*
sweet-scented bedstraw	*Galium triflorum*
tall bluebells	*Mertensia paniculata*
tall Jacob's-ladder	*Polemonium caeruleum*
tall Jacob's-ladder	*Polemonium caeruleum ssp. amygdalinum*
tall larkspur	*Delphinium glaucum*
tall mannagrass	*Glyceria elata*
tamarack	*Larix laricina*
tea-leaved willow	*Salix planifolia*
temporary pelt	*Peltigera didactyla*
thread rush	*Juncus filiformis*
three-leaved false Solomon's-seal	*Smilacina trifolia*
three-toothed saxifrage	*Saxifraga tricuspidata*
toad pelt	*Peltigera scabrosa*
trailing raspberry	*Rubus pubescens*
trembling aspen	*Populus tremuloides*
tundra milk-vetch	*Astragalus umbellatus*
twinflower	*Linnaea borealis*
two-toned sedge	*Carex albonigra*
variable willow	*Salix commutata*
veiny meadowrue	*Thalictrum venulosum*
violet	*Viola sp.*
water birch	*Betula occidentalis*
water sedge	*Carex aquatilis*
western bluegrass	*Poa paucispicula*

Common Name	Scientific Name
western bog-laurel	*Kalmia microphylla*
western dock	*Rumex occidentalis*
western meadowrue	*Thalictrum occidentale*
western mountain-ash	*Sorbus scopulina*
white bog orchid	*Platanthera dilatata*
white mountain-avens	*Dryas octopetala*
white mountain-avens	*Dryas octopetala ssp. octopetala*
white spruce	*Picea glauca*
wild calla	*Calla palustris*
wild lily-of-the-valley	*Maianthemum canadense*
wild sarsaparilla	*Aralia nudicaulis*
wild strawberry	*Fragaria virginiana*
wiry fern moss	*Abietinella abietina*
wood horsetail	*Equisetum sylvaticum*
wood strawberry	*Fragaria vesca*
woodrush	*Luzula sp.*
woolly lousewort	*Pedicularis lanata*
woolly willow	*Salix lanata*
woolly willow	*Salix lanata ssp. richardsonii*
wormseed mustard	*Erysimum cheiranthoides*
yarrow	*Achillea millefolium*
yellow anemone	*Anemone richardsonii*
yellow bog sedge	*Carex gynocrates*
yellow coralroot	*Corallorhiza trifida*
yellow hedysarum	*Hedysarum sulphurescens*
yellow mountain-avens	*Dryas drummondii*

Adapted from the provincial species list (Meidinger et al. 1997).

Appendix 2: Plant Species of the Dunedin Study Area

Scientific Name	Common Name	Authority
coniferous trees		
Abies lasiocarpa	subalpine fir	(Hook.) Nutt.
Larix laricina	tamarack	(Du Roi) K. Koch
Picea glauca	white spruce	(Moench) Voss
Picea mariana	black spruce	(P. Mill.) B.S.P.
Pinus contorta var. latifolia	lodgepole pine	Engelm. ex S. Wats.
broad-leaved trees		
Betula neoalaskana	Alaska paper birch	Sarg.
Betula occidentalis	water birch	Hook.
Betula papyrifera	paper birch	Marsh.
Populus balsamifera ssp. balsamifera	balsam poplar	
Populus tremuloides	trembling aspen	Michx.
evergreen shrubs		
Chamaedaphne calyculata	leatherleaf	(L.) Moench
Juniperus communis	common juniper	L.
Ledum groenlandicum	Labrador tea	Oeder
Ledum palustre ssp. decumbens	northern Labrador tea	(Ait.) Hultén
deciduous shrubs		
Alnus crispa ssp. crispa	green alder	
Alnus crispa ssp. sinuata	Sitka alder	(Regel) Hultén
Alnus tenuifolia	mountain alder	Nutt.
Betula glandulosa	scrub birch	Michx.
Betula pumila	low birch	L.
Cornus stolonifera	red-osier dogwood	Michx.
Lonicera dioica	glaucous-leaved honeysuckle	L.
Myrica gale	sweet gale	L.
Oplopanax horridus	devil's club	Miq.
Potentilla fruticosa	shrubby cinquefoil	L.
Ribes glandulosum	skunk currant	Grauer
Ribes lacustre	black gooseberry	(Pers.) Poir.
Ribes oxyacanthoides	northern gooseberry	L.
Ribes triste	red swamp currant	Pallas
Rosa acicularis	prickly rose	Lindl.
Rubus idaeus	red raspberry	L.
Salix alaxensis	Alaska willow	(Anderss.) Coville
Salix alaxensis var. longistylis	Alaska willow	(Rydb.) Schneid.
Salix arbusculoides	northern bush willow	Anderss.
Salix athabascensis	Athabasca willow	Raup
Salix barrattiana	Barratt's willow	Hook.
Salix bebbiana	Bebb's willow	Sarg.
Salix brachycarpa	short-fruited willow	Nutt.
Salix commutata	variable willow	Bebb
Salix discolor	pussy willow	Muhl.
Salix drummondiana	Drummond's willow	Barratt ex Hook.
Salix exigua	sandbar willow	Nutt.

Scientific Name	Common Name	Authority
Salix farriae	Farr's willow	Ball
Salix glauca	grey-leaved willow	L.
Salix lanata	woolly willow	L.
Salix lanata ssp. richardsonii	woolly willow	(Hook.) Skvort.
Salix maccalliana	MacCalla's willow	Rowlee
Salix myrtillifolia	bilberry willow	Anderss.
Salix myrtillifolia var. cordata	bilberry willow	(Anderss.) Dorn
Salix pedicellaris	bog willow	Pursh
Salix petiolaris	meadow willow	Sm.
Salix planifolia	tea-leaved willow	Pursh
Salix prolixa	Mackenzie's willow	Anderss.
Salix pseudomonticola	mountain willow	Ball
Salix pyrifolia	balsam willow	Anderss.
Salix raupii	Raup's willow	Argus
Salix scouleriana	Scouler's willow	Barratt ex Hook.
Shepherdia canadensis	soopolallie	(L.) Nutt.
Sorbus scopulina	western mountain-ash	Greene
Spiraea stevenii	Steven's spirea	(Schneid.) Rydb.
Vaccinium membranaceum	black huckleberry	Dougl. ex Torr.
Vaccinium uliginosum	bog blueberry	L.
Viburnum edule	highbush-cranberry	(Michx.) Raf.
dwarf woody plants		
Andromeda polifolia	bog-rosemary	L.
Arctostaphylos alpina var. alpina	alpine bearberry	
Arctostaphylos alpina var. rubra	alpine bearberry	(Rehd. & Wilson) Bean
Arctostaphylos uva-ursi	kinnikinnick	(L.) Spreng.
Cassiope tetragona	four-angled mountain-heather	(L.) D. Don
Chimaphila umbellata	prince's-pine	(L.) W. Bart.
Dryas drummondii	yellow mountain-avens	Richards. ex Hook.
Dryas integrifolia	entire-leaved mountain-avens	Vahl
Dryas octopetala	white mountain-avens	L.
Dryas octopetala ssp. octopetala	white mountain-avens	
Empetrum nigrum	crowberry	L.
Kalmia microphylla	western bog-laurel	(Hook.) Heller
Linnaea borealis	twinflower	L.
Luetkea pectinata	partridgefoot	(Pursh) Kuntze
Oxycoccus oxycoccos	bog cranberry	(L.) MacM.
Rhododendron lapponicum	Lapland rosebay	(L.) Wahlenb.
Rubus arcticus	nagoonberry	L.
Rubus chamaemorus	cloudberry	L.
Salix arctica	arctic willow	Pallas
Salix polaris	polar willow	Wahlenb.
Salix reticulata ssp. reticulata	netted willow	
Vaccinium caespitosum	dwarf blueberry	Michx.
Vaccinium vitis-idaea	lingonberry	L.
ferns and fern allies		

Scientific Name	Common Name	Authority
Athyrium filix-femina	lady fern	(L.) Roth
Cystopteris fragilis	fragile fern	(L.) Bernh.
Dryopteris fragrans	fragrant wood fern	(L.) Schott
Equisetum arvense	common horsetail	L.
Equisetum fluviatile	swamp horsetail	L.
Equisetum hyemale	scouring-rush	L.
Equisetum palustre	marsh horsetail	L.
Equisetum pratense	meadow horsetail	Ehrh.
Equisetum scirpoides	dwarf scouring-rush	Michx.
Equisetum sylvaticum	wood horsetail	L.
Gymnocarpium dryopteris	oak fern	(L.) Newman
Lycopodium alpinum	alpine clubmoss	L.
Lycopodium annotinum	stiff clubmoss	L.
Lycopodium clavatum	running clubmoss	L.
Lycopodium complanatum	ground-cedar	L.
Selaginella densa	compact selaginella	Rydb.
graminoids		
Agrostis scabra	hair bentgrass	Willd.
Alopecurus aequalis	little meadow-foxtail	Sobol.
Arctagrostis latifolia	polargrass	(R. Br.) Griseb.
Arctagrostis latifolia var. arundinacea	polargrass	(Trin.) Griseb.
Bromus ciliatus	fringed brome	L.
Bromus sp.	brome	
Calamagrostis canadensis	bluejoint	(Michx.) Beauv.
Calamagrostis rubescens	pinegrass	Buckl.
Calamagrostis stricta	slimstem reedgrass	(Timm) Koel.
Carex aenea	bronze sedge	Fern.
Carex albonigra	two-toned sedge	Mackenzie
Carex aquatilis	water sedge	Wahlenb.
Carex atherodes	awned sedge	Spreng.
Carex brunnescens	brownish sedge	(Pers.) Poir.
Carex canescens	grey sedge	L.
Carex chordorrhiza	cordroot sedge	Ehrh. ex L. f.
Carex diandra	lesser panicled sedge	Schrank
Carex disperma	soft-leaved sedge	Dewey
Carex gynocrates	yellow bog sedge	Wormsk. ex Drej.
Carex macloviana	Falkland Island sedge	d'Urv.
Carex magellanica	poor sedge	Lam.
Carex microchaeta	small-awned sedge	Holm
Carex misandra	short-leaved sedge	R. Br.
Carex nardina	spikenard sedge	Fries
Carex nigricans	black alpine sedge	C.A. Mey.
Carex pauciflora	few-flowered sedge	Lightf.
Carex saxatilis	russet sedge	L.
Carex scirpoidea	single-spike sedge	Michx.
Carex scirpoidea var. scirpoidea	single-spike sedge	
Carex sp.	sedge	

Scientific Name	Common Name	Authority
Carex stylosa	long-styled sedge	C.A. Mey.
Carex supina	spreading arctic sedge	Willd. ex Wahlenb.
Carex tenuiflora	sparse-leaved sedge	Wahlenb.
Carex utriculata	beaked sedge	Boott
Carex vaginata	sheathed sedge	Tausch
Cinna latifolia	nodding wood-reed	(Trev. ex Goepp.) Griseb.
Elymus trachycaulus	slender wheatgrass	(Link) Gould ex Shinners
Eriophorum angustifolium	narrow-leaved cotton-grass	Honckeny
Eriophorum brachyantherum	short-anthered cotton-grass	Trautv. & C.A. Mey.
Eriophorum chamissonis	Chamisso's cotton-grass	C.A. Mey.
Eriophorum gracile	slender cotton-grass	W.D.J. Koch
Eriophorum sp.	cotton-grass	
Eriophorum vaginatum	sheathed cotton-grass	L.
Festuca altaica	Altai fescue	Trin.
Festuca saximontana	Rocky Mountain fescue	Rydb.
Glyceria pulchella		
Hierochloe alpina	alpine sweetgrass	(Sw. ex Willd.) Roemer & J.A. Schultes
Juncus filiformis	thread rush	L.
Kobresia myosuroides	Bellard's kobresia	(Vill.) Fiori
Kobresia simpliciuscula	simple kobresia	(Wahlenb.) Mackenzie
Leymus innovatus	fuzzy-spiked wildrye	(Beal) Pilger
Luzula arctica	arctic woodrush	Blytt
Luzula confusa	confused woodrush	Lindeberg
Luzula parviflora	small-flowered woodrush	(Ehrh.) Desv.
Luzula sp.	woodrush	
Luzula spicata	spiked woodrush	(L.) DC.
Phalaris sp.		
Phleum alpinum	alpine timothy	L.
Poa alpina	alpine bluegrass	L.
Poa arctica	arctic bluegrass	R. Br.
Poa leptocoma	bog bluegrass	Trin.
Poa paucispicula	western bluegrass	Scribn. & Merr.
Poa pratensis	Kentucky bluegrass	L.
Poa sp.	bluegrass	
Poa stenantha	narrow-flowered bluegrass	Trin.
Scirpus microcarpus	small-flowered bulrush	J.& K. Presl
Trisetum spicatum	spike trisetum	(L.) Richter
forbs		
Achillea millefolium	yarrow	L.
Aconitum delphiniifolium	mountain monkshood	DC.
Actaea rubra	baneberry	(Ait.) Willd.
Adoxa moschatellina	moschatel	L.
Anemone narcissiflora	narcissus anemone	L.

Scientific Name	Common Name	Authority
Anemone parviflora	northern anemone	Michx.
Anemone richardsonii	yellow anemone	Hook.
Aralia nudicaulis	wild sarsaparilla	L.
Arnica angustifolia	alpine arnica	Vahl
Arnica cordifolia	heart-leaved arnica	Hook.
Artemisia norvegica	mountain sagewort	Fries
Artemisia tilesii	Aleutian mugwort	Ledeb.
Aster ciliolatus	Lindley's aster	Lindl.
Aster modestus	great northern aster	Lindl.
Aster sibiricus	arctic aster	L.
Astragalus americanus	American milk-vetch	(Hook.) M.E. Jones
Astragalus umbellatus	tundra milk-vetch	Bunge
Calla palustris	wild calla	L.
Calypso bulbosa	fairyslipper	(L.) Oakes
Campanula lasiocarpa	mountain harebell	Cham.
Castilleja miniata	scarlet paintbrush	Dougl. ex Hook.
Castilleja sp.	paintbrush	
Cerastium arvense	field chickweed	L.
Cerastium beeringianum	Bering chickweed	Cham. & Schlecht.
Cicuta douglasii	Douglas' water-hemlock	(DC.) Coult. & Rose
Circaea alpina	enchanter's-nightshade	L.
Coeloglossum viride ssp. bracteatum	long-bracted frog orchid	(Muhl. ex Willd.) Hultén
Cornus canadensis	bunchberry	L.
Delphinium glaucum	tall larkspur	S. Wats.
Drosera rotundifolia	round-leaved sundew	L.
Epilobium angustifolium	fireweed	L.
Epilobium ciliatum ssp. ciliatum	purple-leaved willowherb	
Epilobium latifolium	broad-leaved willowherb	L.
Erigeron acris	bitter fleabane	L.
Erigeron peregrinus ssp. callianthemus	subalpine daisy	(Greene) Cronq.
Erigeron sp.	fleabane	
Erysimum cheiranthoides	wormseed mustard	L.
Fragaria vesca	wood strawberry	L.
Fragaria virginiana	wild strawberry	Duchesne
Galium boreale	northern bedstraw	L.
Galium trifidum	small bedstraw	L.
Galium triflorum	sweet-scented bedstraw	Michx.
Gentiana glauca	glaucous gentian	Pallas
Gentianella propinqua	four-parted gentian	(Richards.) J. Gillett
Geocaulon lividum	bastard toad-flax	(Richards.) Fern.
Geum macrophyllum	large-leaved avens	Willd.
Glyceria elata	tall mannagrass	(Nash ex Rydb.) M.E. Jones
Goodyera repens	dwarf rattlesnake orchid	(L.) R. Br. ex Ait. f.
Hedysarum alpinum	alpine hedysarum	L.
Hedysarum sulphurescens	yellow hedysarum	Rydb.
Heracleum lanatum	cow-parsnip	Michx.
Impatiens noli-tangere	common touch-me-not	L.

Scientific Name	Common Name	Authority
Lathyrus ochroleucus	creamy peavine	Hook.
Leucanthemum integrifolium	entire-leaved daisy	(Richards.) DC.
Listera caurina	northwestern twayblade	Piper
Listera cordata	heart-leaved twayblade	(L.) R. Br. ex Ait. f.
Lupinus arcticus	arctic lupine	S. Wats.
Maianthemum canadense	wild lily-of-the-valley	Desf.
Menyanthes trifoliata	buckbean	L.
Mertensia paniculata	tall bluebells	(Ait.) G. Don
Minuartia rubella	boreal sandwort	(Wahlenb.) Hiern
Mitella nuda	common mitrewort	L.
Moneses uniflora	single delight	(L.) Gray
Myosotis alpestris	mountain forget-me-not	F.W. Schmidt
Orthilia secunda	one-sided wintergreen	(L.) House
Oxytropis maydelliana	Maydell's locoweed	Trautv.
Oxytropis nigrescens	blackish locoweed	(Pallas) Fisch. ex DC.
Oxytropis splendens	showy locoweed	Dougl. ex Hook.
Parnassia fimbriata	fringed grass-of-Parnassus	Koenig
Parnassia palustris	northern grass-of-Parnassus	L.
Pedicularis bracteosa	bracted lousewort	Benth.
Pedicularis capitata	capitate lousewort	M.F. Adams
Pedicularis labradorica	Labrador lousewort	Wirsing
Pedicularis lanata	woolly lousewort	Cham. & Schlecht.
Pedicularis parviflora	small-flowered lousewort	Sm. ex Rees
Pedicularis sp.	lousewort	
Pedicularis sudetica	Sudeten lousewort	Willd.
Petasites frigidus var. frigidus	sweet coltsfoot	
Petasites frigidus var. palmatus	palmate-leaved coltsfoot	(Ait.) Cronq.
Petasites sagittatus	arrow-leaved coltsfoot	(Banks ex Pursh) Gray
Platanthera dilatata	white bog orchid	(Pursh) Lindl. ex Beck
Platanthera obtusata	one-leaved rein orchid	(Banks ex Pursh) Lindl.
Platanthera orbiculata	large round-leaved rein orchid	(Pursh) Lindl.
Polemonium caeruleum	tall Jacob's-ladder	L.
Polemonium caeruleum ssp. amygdalinum	tall Jacob's-ladder	(Wherry) Munz
Polygonum viviparum	alpine bistort	L.
Potentilla diversifolia	diverse-leaved cinquefoil	Lehm.
Potentilla diversifolia var. diversifolia	diverse-leaved cinquefoil	
Potentilla norvegica	Norwegian cinquefoil	L.
Potentilla palustris	marsh cinquefoil	(L.) Scop.
Potentilla uniflora	one-flowered cinquefoil	Ledeb.
Pyrola asarifolia	pink wintergreen	Michx.
Pyrola chlorantha	green wintergreen	Sw.
Pyrola grandiflora	arctic wintergreen	Radius
Ranunculus uncinatus	little buttercup	D. Don ex G. Don
Rorippa palustris	marsh yellow cress	(L.) Bess.
Rubus arcticus	nagoonberry	L.

Scientific Name	Common Name	Authority
Rubus pubescens	trailing raspberry	Raf.
Rumex acetosa	green sorrel	L.
Rumex acetosella	sheep sorrel	L.
Rumex arcticus	arctic dock	Trautv.
Rumex crispus	curled dock	L.
Rumex occidentalis	western dock	S. Wats.
Saxifraga bronchialis	spotted saxifrage	L.
Saxifraga flagellaris	stoloniferous saxifrage	Willd. ex Sternb.
Saxifraga hieraciifolia	hawkweed-leaved saxifrage	Waldst. & Kit.
Saxifraga nelsoniana	cordate-leaved saxifrage	D. Don
Saxifraga oppositifolia	purple mountain saxifrage	L.
Saxifraga sp.	saxifrage	
Saxifraga tricuspidata	three-toothed saxifrage	Rottb.
Scheuchzeria palustris	scheuchzeria	L.
Senecio lugens	black-tipped groundsel	Richards.
Senecio triangularis	arrow-leaved groundsel	Hook.
Silene acaulis	moss campion	(L.) Jacq.
Silene uralensis ssp. attenuata	apetalous campion	(Farr) McNeill
Smilacina trifolia	three-leaved false Solomon's-seal	(L.) Desf.
Solidago canadensis	Canada goldenrod	L.
Solidago multiradiata	northern goldenrod	Ait.
Solidago spathulata	spike-like goldenrod	DC.
Sparganium angustifolium	narrow-leaved bur-reed	Michx.
Spiranthes romanzoffiana	hooded ladies' tresses	Cham.
Stellaria longipes	long-stalked starwort	Goldie
Streptopus amplexifolius	clasping twistedstalk	(L.) DC.
Thalictrum occidentale	western meadowrue	Gray
Thalictrum sp.	meadowrue	
Thalictrum sparsiflorum	few-flowered meadowrue	Turcz. ex Fisch. & C.A. Mey.
Thalictrum venulosum	veiny meadowrue	Trel.
Tofieldia pusilla	common false asphodel	(Michx.) Pers.
Urtica dioica	stinging nettle	L.
Valeriana dioica	marsh valerian	L.
Veratrum viride	Indian hellebore	Ait.
Veronica beccabunga	American speedwell	L.
Vicia americana	American vetch	Muhl. ex Willd.
Viola glabella	stream violet	Nutt.
Viola palustris	marsh violet	L.
Viola renifolia	kidney-leaved violet	Gray
Viola sp.	violet	
Zigadenus elegans	mountain death-camas	Pursh
saprophyte		
Corallorhiza trifida	yellow coralroot	Chatelain
mosses		

Scientific Name	Common Name	Authority
Abietinella abietina	wiry fern moss	(Hedw.) Fleisch.
Aulacomnium palustre	glow moss	(Hedw.) Schwaegr.
Aulacomnium turgidum		(Wahlenb.) Schwaegr.
Brachymenium asperrimum		(Mitt.) Sull.
Brachythecium salebrosum	golden ragged moss	(Web. & Mohr) Schimp. in B.S.G.
Brachythecium sp.		
Brachythecium turgidum		(C. J. Hartm.) Kindb.
Brachythecium velutinum		(Hedw.) Schimp. in B.S.G.
Bryum argenteum		Hedw.
Bryum caespiticium		Hedw.
Calliergon cordifolium		(Hedw.) Kindb.
Ceratodon purpureus	fire moss	(Hedw.) Brid.
Dicranella schreberiana		(Hedw.) Hilf. ex Crum & Anderson
Dicranella sp.		
Dicranum acutifolium		(Lindb. & Arnell) C. Jens. ex Weinm.
Dicranum elongatum		Schleich. ex Schwaegr.
Dicranum fuscescens	curly heron's-bill moss	Turn.
Dicranum scoparium	broom moss	Hedw.
Drepanocladus aduncus		(Hedw.) Warnst.
Drepanocladus uncinatus	sickle moss	(Hedw.) Warnst.
Drepanocladus vernicosus		(Mitt.) Warnst.
Eurhynchium pulchellum		(Hedw.) Jenn.
Eurhynchium sp.		
Hylocomium splendens	step moss	(Hedw.) Schimp. in B.S.G.
Hypnum lindbergii		Mitt.
Hypnum procerrimum		Mol.
Hypnum vaucheri		Lesq.
Kiaeria sp.		
Lescuraea radicosa		(Mitt.) Mönk.
Meesia triquetra		(Richt.) Ångstr.
Orthothecium chryseum		(Schwaegr. in Schultes) Schimp. in B.S.G.
Orthotrichum sp.		
Plagiomnium drummondii	Drummond's leafy moss	(Bruch & Schimp.) T. Kop.
Plagiomnium ellipticum		(Brid.) T. Kop.
Plagiomnium insigne	coastal leafy moss	(Mitt.) T. Kop.
Plagiomnium medium	common leafy moss	(Bruch & Schimp. in B.S.G.) T. Kop.
Plagiomnium rostratum		(Schrad.) T. Kop.
Pleurozium schreberi	red-stemmed feathermoss	(Brid.) Mitt.
Pohlia sp.		
Polytrichum commune		Hedw.
Polytrichum juniperinum	juniper haircap moss	Hedw.
Polytrichum piliferum	awned haircap moss	Hedw.
Polytrichum sp.		

Scientific Name	Common Name	Authority
Polytrichum strictum	bog haircap moss	Brid.
Pseudoleskeela nervosa		
Ptilium crista-castrensis	knight's plume	(Hedw.) De Not.
Racomitrium lanuginosum	hoary rock moss	(Hedw.) Brid.
Rhytidium rugosum	crumpled-leaf moss	(Hedw.) Kindb.
Sphagnum angustifolium		(C. Jens. ex Russ.) C. Jens. in Tolf
Sphagnum capillifolium	common red sphagnum	(Ehrh.) Hedw.
Sphagnum fuscum	common brown sphagnum	(Schimp.) Klinggr.
Sphagnum girgensohnii	common green sphagnum	Russ.
Sphagnum magellanicum		Brid.
Sphagnum recurvum		
Sphagnum warnstorfii		Russ.
Splachnum sp.		
Timmia austriaca	false-polytrichum	Hedw.
Tomentypnum nitens	golden fuzzy fen moss	(Hedw.) Loeske
Tortella fragilis		(Hook. & Wils in Drumm.) Limpr.
Tortula norvegica		(Web.) Wahlenb. ex Lindb.
Tortula ruralis	sidewalk moss	(Hedw.) Gaertn. et al.
liverworts		
Lophozia sp.		
Ptilidium ciliare		(L.) Hampe
lichens		
Alectoria ochroleuca		(Hoffm.) A. Massal.
Alectoria sp.		
Bryocaulon divergens		(Ach.) Kärnefelt
Bryoria sp.		
Cetraria ericetorum	icelandmoss	Opiz
Cetraria islandica ssp. islandica	icelandmoss	
Cladina arbuscula ssp. mitis		(Sandst.) Burgaz
Cladina rangiferina	grey reindeer lichen	(L.) Nyl.
Cladina stellaris		(Opiz) Brodo
Cladonia amaurocraea		(Flörke) Schaerer
Cladonia borealis	red pixie cup	S. Stenroos
Cladonia botrytes		(K. Hagen) Willd.
Cladonia cariosa	ribbed cladonia	(Ach.) Sprengel
Cladonia cenotea		(Ach.) Schaerer
Cladonia chlorophaea		(Flörke ex Sommerf.) Sprengel
Cladonia cornuta	horn cladonia	(L.) Hoffm.
Cladonia deformis		(L.) Hoffm.
Cladonia gracilis ssp. turbinata	black-foot cladonia	(Ach.) Ahti
Cladonia multiformis		G. Merr.
Cladonia pleurota		(Flörke) Schaerer
Cladonia pyxidata	brown pixie cup	(L.) Hoffm.
Cladonia sulphurina	sulphur cladonia	(Michaux) Fr.

Scientific Name	Common Name	Authority
Cladonia uncialis		(L.) F. H. Wigg.
Dactylina arctica	few-finger lichen	(Richardson) Nyl.
Flavocetraria cucullata		(Bellardi) Kärnefelt & Thell
Flavocetraria nivalis	ragged snow	(L.) Kärnefelt & Thell
Icmadophila ericetorum	spraypaint	(L.) Zahlbr.
Nephroma arcticum	green paw	(L.) Torss.
Peltigera aphthosa	freckle pelt	(L.) Willd.
Peltigera didactyla	temporary pelt	(With.) J. R. Laundon
Peltigera malacea	apple pelt	(Ach.) Funck
Peltigera ponojensis	felt pelt	Gyelnik
Peltigera scabrosa	toad pelt	Th. Fr.
Peltigera sp.	pelt lichens	
Pertusaria sp.		
Psora decipiens	sockeye psora	(Hedwig) Hoffm.
Stereocaulon alpinum		Laurer ex Funck
Stereocaulon tomentosum		Fr.
Thamnolia vermicularis	rock worm lichen	(Sw.) Ach. ex Schaerer
Umbilicaria muehlenbergii	plated rocktripe	(Ach.) Tuck.
Vulpicida tilesii	limestone sunshine	(Ach.) J.-E. Mattsson & M. J. Lai

Adapted from the provincial species list (Meidinger et al. 1997).

Appendix 3: Detailed Plot Numbers

Correspondence between unique plot numbers used in the provincial database and field numbers that appear on Dunedin ecosystem maps.

Field Number	Provincial Database Plot Number	Field Number	Provincial Database Plot Number	Field Number	Provincial Database Plot Number
B2	9621247	K24	9623771	S51	9621192
B3	9629192	K27	9623773	S62	9623693
B6	9629195	K36	9623683	S69	9621189
J1	9612938	K43	9623685	S100	9623962
J10	9612945	K44	9623686	S103	9623964
J15	9612948	K46	9621177	S109	9623969
J23	9623986	K100	9621265	S110	9623970
J33	9621212	K104	9623977	S116	9621187
J35	9621213	K111	9623979	S128	9621228
J46	9623993	K145	9621234	S133	9621181
J49	9623995	K147	9621236	S140	9621286
J57	9623998	S3	9621135	S141	9629199
J73	9621217	S12	9621141	S151	9621280
K1	9623848	S14	9621142	W103	9621263
K2	9623849	S18	9623600	W104	9621261
K4	9623850	S23	9620756	W116	9621206
K8	9623766	S25	9623760	W120	9621198
K9	9623767	S28	9623762	W134	9621288
K10	9621145	S30	9623763	W135	9621287
K13	9621147	S43	9621168	W136	9621300
K18	9621163	S50	9621193	W137	9621299

Appendix 4: Aerial Photographs Used in Mapping

Flight Line Number	Aerial Photograph Number
15BC86036	281-286
15BC86046	001-009, 058-066, 153-160, 166-173
15BC86072	172-182, 188-199, 218-226
15BC86077	265-273
15BC87049	047-054, 057-067, 086-093

Appendix 5: Final Ratings Tables

This appendix provides suitability and capability ratings values for each mapped ecosystem. Suitability ratings are provided for each of the rated life requisites and seasons for each species. The structural stage with the highest rating will be the capability for the ecosystem. Definitions for the codes used in the final ratings table are provided in Table A1.

Table A1: Legend for Wildlife Capability and Suitability Ratings

<u>Species Codes</u>

MURAR	grizzly bear
MMAPE	fisher
MMAAM	marten
MALAL	moose
MCEEL	Rocky Mountain elk
MODHH	mule deer
MODVS	Stone’s sheep
MRATA	woodland caribou

<u>Life Requisites</u>

LI	living
FD	feeding
SH	security
ST	security/thermal
HI	hibernating
RB	reproducing (birthing)

<u>Seasons</u>

P	spring
S	summer
F	fall
W	winter
G	growing
EW	early winter
LW	late winter

<u>Habitat Capability and Suitability Rating Schemes</u>

4 class rating scheme:

H	high (100 - 76% of provincial standard)
M	moderate (75 - 26% of provincial standard)
L	low (25 - 1% of provincial standard)
N	nil (0% of provincial standard)

6 class ratings scheme:

1	high (100 - 76% of provincial standard)
2	moderately high (75 - 51% of provincial standard)
3	moderate (50 - 26% of provincial standard)
4	low (25 - 6% of provincial standard)
5	very low (5 - 1% of provincial standard)
6	nil (0% of provincial standard)

Appendix 6: Additional Species – Habitat Model

The Cape May warbler was originally included as one of the species in the contract for the Dunedin study area, and a draft species account and partial preliminary ratings table was completed. Subsequently, through discussions with the contract monitor, it was agreed the information level regarding distribution and habitat requirements was insufficient to produce complete models for the Cape May warbler at this time. This species was therefore removed from the project species list, but the compiled preliminary information has been included here as it may prove useful in subsequent research/work.

Preliminary Species - Habitat Model for Cape May Warbler

Common Name:	**Cape May Warbler**
Scientific Name:	*Dendroica tigrina*
Species Code:	B-CMWA
B.C. Status:	Red-listed (B.C. MoELP 1996, B.C. CDC 1997)
Identified Wildlife Status:	None
COSEWIC Status:	Not applicable

Distribution

The Cape May warbler is a neotropical migrant songbird[3] whose breeding distribution within Canada extends west from Nova Scotia to the southwestern Northwest Territories and northeastern British Columbia (Godfrey, 1986). It winters mainly in the West Indies, although some birds winter in Central and South America (American Ornithologists' Union 1983, in Cooper *et al.,* 1997).

Provincial Range

The Cape May warbler is rare within British Columbia, found only in very small and scattered populations within the forests of British Columbia, almost exclusively within the Taiga Plains and Boreal Plains ecoprovinces (Cooper *et al.,* 1997). A recent study by Bennett and Enns (1996) found presence and probable breeding of Cape May warblers along the Liard river to the north of the study area. This species has been recorded near Fort Nelson, mostly along the Kledo Creek and Fort Nelson rivers (Enns and Siddle, 1996). Cape May warblers have also been detected in the southeastern Yukon where there is evidence of probable breeding (Sinclair, 1996).

Distribution in the Study Area

The Cape May warbler has been recorded within the ETP ecosection of the Taiga Plains ecoprovince and probably occurs in all other ecosections of this ecoprovince (Cooper *et al.,* 1997). It has been recorded within the MUP ecosection (Enns and Siddle, 1996) and within both the BWBSmw1 and BWBSmw2 variants (Cooper *et al.,* 1997). Cape May warblers were recorded in the Dunedin (around the airstrip and in old growth habitat at the mainstem of the Dunedin) during a recent bird inventory (summer 1998) completed in the Smith River area of northeastern B.C. (L. Wilkinson, pers. comm.). Cape May warbler occurrence within the ecoregions, ecosections, and biogeoclimatic zones of the study area is summarized in Table A2. Cape May warblers probably breed within suitable habitat in the Dunedin study area, and it may be an important area for this bird in British Columbia.

[3]Neotropical migrants are birds that breed in temperate regions and winter in tropical regions.

Table A2: Expected Cape May Warbler Occurrence within the 6 Ecosection - BEC Variant Combinations Found within the Dunedin Study Area

Ecoprovinces	TAIGA PLAINS		NORTHERN BOREAL MOUNTAINS			
Ecoregions	Muskwa Plateau		Northern Canadian Rocky Mountains			
Ecosections	MUP		MUF			
BEC Variants	BWBSmw2	BWBSwk3	BWBSmw2	SWBmk	SWBmks	AT
Species						
Cape May Warbler	•	?	•?	x	x	x

Legend:
- = occurs in the variant
•? = probably occurs in the variant
? = unlikely to occur in the variant
x = essentially absent

Elevational Range
Elevations within the Dunedin study area range from approximately 250 m to 2,105 m. The elevational range of Cape May warblers is not well described. Enns and Siddle (1996) found most Cape May warblers at elevations above 450 m in the Liard river area to the north of the Dunedin study area where elevations ranged from approximately 250 m to 640 m. Within the Dunedin study area, Cape May warblers are probably restricted to the BWBS biogeoclimatic zone.

Ecology and Habitat Requirements
The Cape May warbler is associated with late successional coniferous-dominated forests (Cooper *et al.,* 1997). For the most part, this species' breeding distribution and population size are thought to fluctuate with changing spruce budworm populations (Morse, 1978 in Cooper *et al.,* 1997). A proposed Cape May warbler habitat model may be found in Enns and Siddle (1996), and a complete synthesis of available information on Cape May warblers may be found in Cooper *et al.* (1997).

Habitat Use (Life Requisites and Seasons)
The only life requisite that is rated for the Cape May warbler is reproducing in the growing season as this bird is a migrant that winters elsewhere and will therefore not be present in British Columbia at other times of the year. The rated life requisite is summarized in Table A3.

Table A3: Summary of Rated Life Requisite and Season for the Cape May Warbler in the Dunedin Study Area

Rated Life Requisite and Season	Code	Months of Use
Reproducing by eggs - security	RE_SH	June-July

Ecosystem units are not rated for food values for reproducing (RE-FD) as food requirements are assumed to be fulfilled in habitat suitable for nesting.

Reproduction
The Cape May warbler is dependent on mature and old-growth white spruce and mixed-wood forests for breeding habitat (Cooper *et al.,* 1997). Bennett and Enns (1996) also show Cape May warblers to be associated with mature coniferous stands with the majority of birds found in black and white spruce dominated stands where they forage mostly within the upper

canopy (Enns and Siddle, 1996). Cape May warblers nest near the tops of coniferous trees (mainly spruce) generally from 10 m to 20 m above the ground (Cooper *et al.,* 1997). Very tall conifers, which extend above the main canopy, are used as singing posts by males (Semenchuck, 1992 in Enns and Siddle, 1996). Typical Cape May warbler habitat includes stands that are "often tall, dense of mature white spruce on flat ground with an open mossy understory, occasional gaps (either natural or man-induced), with scattered spires above the canopy" (Bennett and Enns, 1996).

Seasons of Use

Tables A4 summarizes the rated life requisite for the Cape May warbler for each month of the year.

Table A4: Monthly Rated Life Requisites for the Cape May Warbler in the Dunedin Study Area

Month	Season*	Rated Life Requisites
January	W	NA
February	W	NA
March	W	NA
April	W	NA
May	G	NA
June	G	RE-SH
July	G	RE-SH
August	G	NA
September	G	NA
October	W	NA
November	W	NA
December	W	NA

Legend
W=Winter G=Growing RE=Reproducing (eggs) SH=security NA=Not applicable
*Seasons defined per the Chart of Seasons by Ecoprovince (RIC, 1998; Appendix B).

Spring migrants enter northeastern B.C. beginning in mid May through early June. Egg-laying probably occurs in mid-to-late June, and nestlings are probably present from late June through mid July in northeastern B.C. Adults probably migrate south in mid-to-late July with juveniles following in August (Cooper *et al.,* 1997). For this model, the estimated breeding season is defined as mid June to mid July.

Habitat Use and Ecosystem Attributes

Table A5 outlines how the rated life requisite relates to specific ecosystem attributes.

Table A5: Terrestrial Ecosystem Mapping (TEM) Relationships for each Life Requisite for the Cape May Warbler

Life Requisite	Ecosystem Attribute
Reproducing Habitat (security)	site: elevation, structural stage, site disturbance vegetation: % cover by layer, species list by layer, cover for each species for each layer - structural stages 6 and 7 most valuable, coniferous forests

Development of the Habitat Ratings

Rating Scheme

A 4-class rating scheme (requiring an intermediate knowledge of habitat use) of high (H), moderate (M), low (L), and nil (N) is employed as suggested by RIC (1998) for Cape May warblers. The used ratings scheme is defined in Table A6.

Table A6: Habitat capability and suitability 4-class rating scheme (from RIC, 1998)

% of Provincial Best	Rating	Code
100% - 76%	High	H
75% - 26%	Moderate	M
25% - 1%	Low	L
0%	Nil	N

This rating scheme is used when assigning habitat ratings to the ecosystem units present within the Dunedin study area. The habitat ratings express the ability of the units to fulfil habitat requirements for reproducing by the Cape May warbler, as previously outlined in Table A3.

Provincial Benchmark

A provincial benchmark has not yet been established for the Cape May warbler. This species is restricted in B.C. to the boreal forests of the northeast (Cooper *et al*., 1997) and therefore the BWBSmw2 variant will be rated up to Class 1 habitat.

Ratings Assumptions

Preliminary habitat ratings were not developed for the BWBSwk3, SWBmk, SWBmks, and AT as the site series for these variants were still being developed at the time the Cape May warbler was removed from the project species list. However, ratings for all units of the SWBmk, SWBmks, and AT will be nil as suitable nesting habitat is not present at these higher elevations.

Preliminary habitat ratings for the BWBSmw2 variant for the Cape May warbler are presented in Table A7. Further study is needed to validate and refine these ratings. The following assumptions have been made:

- Cape May warblers nest high in coniferous trees (mainly spruce), and most foraging occurs in the upper canopy (Cooper *et al*., 1997; Enns and Siddle, 1996). Therefore, structural stages 1 to 5 are considered to have minimal nesting and foraging value and are given ratings of nil. Due to this species dependence on mature and old growth forest, stages 6 to 7 are considered the most valuable structural stages in terms of nesting and foraging attributes.
- Spruce and spruce dominated stands provide preferred habitat and are therefore rated as having high value. Bennett and Enns (1996) found white and black spruce often made up over 90% of the forested cover in locations where Cape May warblers were found. Pure deciduous stands and those with a high component of deciduous trees are given low ratings. Cape May warblers are generally found in closed canopy stands with >60% canopy closure (yet they may occasionally be found in more open stands with <25% canopy closure) (Bennett and Enns, 1996).

- Cape May warblers will generally be found more in subhygric sites with understories that tend to be open and mossy. Bennett and Enns (1996) found a very open understory dominated by mosses and herbs with sparse alder and highbush cranberry was preferred. Enns and Siddle (1996) found associated understory species to include highbush cranberry, bunchberry, palmate coltsfoot, willow, and twinflower.
- Slope of Cape May warbler nesting habitat is generally level to gently sloping (Cooper *et al.,* 1997).
- Within the BWBSmw2, Cape May warblers are most often associated with the subhygric White Spruce-Currant-Horsetail (05) site series occurring on level to gently sloping river terraces (Cooper *et al*., 1997).

Table A7: Cape May Warbler Nesting Habitat Ratings for the Forested Ecosystems of the BWBSmw2 of the Dunedin Study Area

Structural Stage	3	4	5	6	7
Life Requisite	RE-SH	RE-SH	RE-SH	RE-SH	RE-SH
Forested Ecosystem Units					
AM - SwAt-Step moss (01)	N	N	N	M-H	M-H
AM - SwAt-Step moss (01$)	N	N	N	L	L
LL - Pl-Ligonberry-Velvet-leaved blueberry (02)	N	N	N	L	L
BK - Sw-Wildrye-Peavine (03)	N	N	N	L-M	L-M
BL - Sb-Logonberry-Coltsfoot (04)	N	N	N	M-H	M-H
SH - Sw-Currant-Oak fern (05)	N	N	N?	H	H
SH - Sw-Currant-Oak fern (05$)	N	N	N	L-M	L-M
BB - Sw-Currant-Bluebells (06)	N	N	N	M	M
BS - Sb-Labrador tea-Sphagnum (08)	N	NA	NA	NA	NA
TB - Lt-Buckbean (10)	N	NA	NA	NA	NA

Legend
H=High M=Moderate L=Low N=Nil NA=Not Applicable RE=Reproducing (eggs) SH=Security Habitat
$=Seral stage dominated by deciduous trees

Rating Adjustment Considerations

As Cape May warblers are dependent on interior forest conditions (Bennett and Enns, 1996), forest fragmentation will probably cause nesting habitat values to be downgraded. Habitat fragmentation can also result in increased cowbird parasitism, reducing the value of habitats (Cooper *et al*., 1997).

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ECOSYSTEM MAPS