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PREDICTING THE DISTRIBUTION OF MOUNTAIN CARIBOU, WOLVERINE, FISHER, AND GRIZZLY BEAR IN PRINCE GEORGE FOREST DISTRICT: I. HABITAT PARAMETERS

by

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INTRODUCTION

In British Columbia, general measures have been developed to manage biodiversity at landscape and stand levels (B.C. Ministries of Forest and Environment 1995a, b). These management approaches are *"coarse filter"* strategies to conserve a variety of wildlife species. Whereas such measures may not be sufficient to ensure the conservation of special status species, *"fine filter"* management guidelines are required to ensure that species at risk are maintained throughout ecosystems (Canfor 2002). However, in order to develop landscape- and stand- level management programs for species at risk, it is necessary to have *a priori* an understanding of the probable distribution of such species. This project is a first step in the development of management strategies to predict and manage habitats of species at risk.

In the Prince George Forest District, there are currently 12 vertebrate species[1] that received the status of "*identified wildlife*", i.e., species at risk that require special management attention and are protected under the Forest Practice Code of British Columbia (Proulx et al. 2002). Proulx (2003) pointed out that there was a lack of tools to predict the distribution of mountain caribou (*Rangifier tarandus*), grizzly bear (*Ursus arctos*), fisher (*Martes pennanti*), wolverine (*Gulo gulo*), and mountain goat (*Oreamnos americanus*), and properly assess the impact of forest activities in Canfor's Planning Areas. Proulx's (2003) conclusion echoed assessments made by other wildlife professionals (e.g., Gyug 2002, Cichowski 2003, Weir 2003a,b). It is therefore necessary to develop habitat predictive models for these species. Such a model has been initiated by Slocan (Mackenzie District) for mountain goat (D. Heard, WLAP, 2003, pers. commun.).

OBJECTIVES

This project aimed to identify parameters that can be used in queries to develop predictive distribution maps for mountain caribou, wolverine, fisher, and grizzly bear in Prince George Forest District.

METHODOLOGY

An extensive review of scientific journals, books, symposia, and technical reports was conducted in order to gain a proper understanding of the relationships existing between selected species and their habitats. Although the ecological needs of the species were reviewed throughout their entire range of distribution, special emphasis was given to western boreal, subalpine, and montane regions (Rowe 1972). Also, whenever possible, this report integrated local data gathered in Prince George Region. This was done through a review of regional reports, and meetings with species specialists.

[1] The list of *identified wildlife* is under review, and a new list of species will be released in fall 2003. Species that have been selected in this project will still be part of the revised list (K. Paige, 2003, B.C. Ministry Water, Land and Air Pollution, Victoria, pers. commun.).

A Brief Species Account

Information relative to the species characteristics, distribution, breeding season, and social interactions is briefly reviewed so that the reader understands the peculiarities of the biology of the species. Information about prey and food items is also provided because these species' needs impact directly on the species at risk movements and habitat requirements. The brief account includes the following sub-sections:

1. *Description*
2. *Status*
3. *Distribution*
4. *Population Dynamics*
5. *Home Ranges*
6. *Food Habits*
7. *Threats*

Habitat Requirements

Since the objective of this project is to predict the distribution of species at risk according to stand characteristics across landscapes, the species' habitat requirements obviously deserve special attention. When reviewing the habitats of species at risk, information from various ecosections has been collated and paradigms were identified.

Spatial-dependent Criteria

Johnson (1980) introduced the concept that animals select resources at several different spatial scales, which he labeled "selection orders". A selection process is of higher order than another if it is conditional upon the latter. In this project, the 1st order corresponds to the geographic extent of the species; the 2nd order, the selection of a home range; the 3rd order, the selection of stands within the home range; and the 4th order, the selection of particular sites for specific activities such as denning, resting, etc.

Although the 1st order must be considered for the development of refugia over large areas and the identification of movement corridors between watersheds (Soulé and Terborgh 1999), this order is too large to allow one to assess the importance of specific parameters on the utilization of sites by a species at risk. The 4th order is very important as it corresponds to special habitat features (elements) that are vital to the ecology of a species. While such elements may be identified during the literature review, they may not help to develop queries because they may not be part of datasets used to map forest habitats across landscapes. For example, although > 40-cm-diameter coarse woody debris may be important for fisher during cold weather, and boulders may be used by wolverines in the selection of a subnivean den, these elements are not recorded in datasets used for the production of forest cover maps. They may have been recorded in TEM datasets.

On the other hand, habitats (2nd order - home range, and 3rd order – stands therein) may be identified using current datasets (Proulx and Kariz 2002). If 2nd and 3rd orders are properly selected on the basis of ecologically significant variables, selected areas will inevitably encompass 1st order elements that are critical for a species at risk. For example, if an animal requires large amounts of coarse woody debris and overhead cover in the SBS biogeoclimatic, the selection of >120-year-old spruce-dominated stands will likely provide it with the required structural complexity. When done across adjacent landscapes, the selection of 2nd and 3rd order areas will indicate the extent of connectivity (or the lack thereof) between suitable habitats from different watersheds.

When reviewing species' habitat requirements, it is therefore important to focus on 2nd and 3rd orders, and identify criteria that can be used in queries for the development of predictive maps. In other words, knowledge about the habitat requirements of a species must be translated into a series of quantifiable parameters, which have been inventoried in the past for the production of forest cover maps using diverse databases such as VRI, TEM and PEM. Nevertheless, for sake of thoroughness, elements of the 4th order that could be used in queries with detailed datasets will be reported within the selection of parameters.

In the development of maps to predict the distribution of American marten (*Martes americana*) across the landscape, Proulx and Kariz (2001a, 2002) successfully identified a series of parameters that efficiently summarized the habitat needs of the species, and that was compatible with forestry inventory datasets. Because marten's habitat requirements are as complex and numerous as those of species studied in this project, Proulx and Kariz's (2001a) series of variables was adopted as a starting point. Therefore, at stand level, special attention was paid to: 1) cover type; 2) successional type; 3) canopy closure; 4) basal area and tree characteristics; 5) site type (xeric, mesic); 6) understory; 7) coarse woody debris and snags (data often limited to presence/absence); and 8) habitat origins (e.g., IU-logged 50 years ago *vs*. undisturbed for > 80 years). At landscape level, special attention was paid to contiguity, percent of cover types, elevations, and connectivity. Because information about above-noted parameters is sometimes lacking for a species at risk, prescriptions that successfully provide for the life needs of prey or sympatric species (Appendix I) were used to complete the selection of habitat parameters for predictive maps.

WOLVERINE

Species Account

Description

The wolverine looks like a small bear (males: 11-16 kg; females: 6.5-15 kg). Pelage varies from dark brown to almost black, with a lighter facial mask and throat patch, and two yellowish stripes extending from the shoulders to the rump and merging into the tail (Proulx et al. 2002).

Status

The species is blue-listed in British Columbia. Although no reliable population estimate exists for the Province and its diverse regions, an estimate of 1 wolverine/160 km^2 appears to be realistic (Weir 2003a). Wolverine populations are managed as Class 2 furbearers, i.e., that move among traplines, are vulnerable to overtrapping, and generally not found in manageable numbers within a single registered trapline.

Distribution

Wolverines are widely distributed throughout much of British Columbia. They are present throughout the Prince George Region, particularly in areas remote from urban development. They inhabit ICH, SBS, ESSF and AT biogeoclimatic units (Proulx et al. 2002).

Population Dynamics

Wolverines breed between late April and early September but embryos do not implant in the uterus until January. The condition of females before implantation may be the most critical factor determining successful birth (Banci 1994). They give birth between February and mid-April to 1-5 kits. In the Omineca region, on the basis of very limited data, litter sizes averaged 3. Litter size after den abandonment is approximately 2-3 (Pulliainen 1968, Magoun 1985, Lofroth 2001). Females do not breed during their first summer; sexual maturity in males is generally not reached until 2 years of age (Rausch and Pearson 1972, Banci and Harestad 1988).

Wolverines may be killed by large carnivores or conspecifics (Magoun 1985, Banci 1987). Starvation is an important mortality factor (Banci 1987). Trapping is the primary mortality factor (Banci and Proulx 1999).

Home Ranges

Home ranges of adult wolverines vary regionally according to habitat quality, and seasonally according to animal activity (e.g., breeding, non-breeding, dispersal, etc.), and prey distribution and availability. Home range sizes vary roughly from 100 to1000 km^2 (Hornocker and Hash 1981, Gardner 1985, Magoun 1985, Whitman et al. 1986, Banci 1987).

Adult male home ranges are usually larger (typically 3 times) than those of females; also, females with young have a smaller home range than those without young (Banci 1987, Lofroth 2001). Only adult wolverines maintain distinct home ranges. Male home ranges overlap with one or more females, and other males. Females' home ranges do not overlap with other females (Krebs and Lewis 2000). Home ranges are maintained between years.

In the Omineca region, home ranges varied in size from as low as 158 km^2 for a female, to as high as 4572 km^2 for a dispersing juvenile male. Home ranges of adult females are relatively small and enclose a significant portion of high elevation habitat (see more details under Habitat Requirements).

Food Habits

Wolverines are generally described as opportunistic omnivores in summer and primarily scavengers/predators in winter. Wolverines prey on ungulates in deep snow and when they are vulnerable (e.g., calving season). In the absence of carrion, they may feed on small mammals and ground-dwelling sciurids, snowshoe hare (*Lepus americanus*), and ground-nesting birds. Berries can be important in fall, and during late winter and spring (Rausch and Pearson 1972, Banci 1987,1994).

In the Omineca region, moose are consumed throughout the year by all ages and sex classes. However, during summer, adult females with kits included hoary marmots (*Marmota caligata*) and caribou as substantial portions of their diet (Lofroth 2001). Wolverines are capable of killing caribou (Hatler 1989, Lofroth 2001).

Main prey species have the following habitat requirements:

Moose (*Alces alces*): Optimum moose habitat contains a wide variety of stand types and age classes that provide both open disturbed areas for food, and mature coniferous cover for security (Peek 1997). In the boreal forest, moose winter habitat is characterized by a mix or relatively closed canopied, multilayered conifer forests (41-80%), with heights of 9-18 m, interspersed with young stands rich in browse (Proulx and Joyal 1981, Proulx 1983). In the north-central interior of British Columbia, Proulx and Kariz (2001b) found similar results and recommended management programs maintaining mosaics of immature stands, scrub, spruce-dominated young stands, and mature forests other than pine-leading types.

Mountain Caribou: Throughout the winter, caribou use old forests (basal area of live trees of 20-25 m^2/ha) and avoid immature stands. In early winter, as snow is accumulating to depths of 3 m or more in the upper ESSF, caribou use the lower parts of the ESSF zone and the ICH biogeoclimatic zone, where snow is not as deep. Most stands used by caribou in early winter are commercially valuable. Shrubs supplement lichen forage until snow burial makes them unavailable. As snow densities increase to levels that will support caribou, the animals move up in elevation; for the rest of the winter, they feed almost exclusively on arboreal lichens in stands that are non-merchantable (Stevenson et al. 2001, Proulx et al. 2002). As the elevations become snow free, caribou move up into the high elevation ESSF, ESSF parkland and further into alpine meadows. The majority of the summer months and early fall is spent in these areas.

Hoary Marmots: Active life for a hoary marmot corresponds to a very short period of approximately four months per year. Hoary marmots usually inhabit alpine and subapline mountain slopes. They also utilize subalpine meadows and rocky outcroppings. In the

Omineca, marmots inhabit alpine meadow, tundra, shrublands, and talus, locating their burrow under rocks (Lofroth 2001).

Snowshoe hare: Habitats with a conifer overstory and a dense understory of 1-3 m tall stems are preferred by hares (Wolfe et al. 1982, Pietz and Tester 1983, Monthey 1986, Thompson 1988, Koehler 1990, 1991, Koehler and Aubry 1994). Conroy et al. (1979) found that stands with a basal area of 20-30 m^2 /ha in cedar (*Thuja* spp.) and fir (*Abies* spp.) provided the best overstory in winter. Habitats with understories providing > 40% horizontal cover and > 40% visual obstruction (> 15 m) in winter offer snowshoe hares protective (Keith and Surrendi 1971), Wolfe et al. 1982, Litvaitis et al. 1985) and thermal (Verme 1965) cover. Snowshoe hares are rarely found far out in open areas, although they may cross them to reach a cover area (Dodds 1987). Conroy et al. (1979) reported that high densities of hares will not be found farther than 200-400 m from cover; likewise, high densities are less likely to be found in areas with a solid canopy than in areas with high habitat interspersion.

Ground-nesting birds: Spruce Grouse (*Dendragrapus canadensis*) inhabit mixed coniferous forests with medium-light shrub density. They inhabit lodgepole pine (P*inus contorta*) , Engelmann spruce (*Picea engelmannii*), and subalpine fir (*Abies lasiocarpa*) stands where they feed on conifer needles (Pendergast 1969, Cannings et al. 1987). In winter, Ruffed Grouse (*Bonasa umbellus*) frequently use coniferous forests for shelter (Campbell et al. 1990). In spring, more open mixed and deciduous woodlands nearby water are occupied (Campbell et al. 1990, Hutto and Young 1999). White-tailed Ptarmigans (*Lagopus leucurus*) frequent subalpine and alpine habitats including rocky unvegetated areas, rockslides, alpine meadows, krummholtz, logged and burned subalpine forests, screes, and lake and stream shores. It breeds in alpine areas (Campbell et al. 1990).

Threats

The primary population threat is additive mortality resulting from fur harvesting. Banci and Proulx (1999) rated wolverine as a low resiliency species, i.e., with limited capability to recover from a reduction in numbers, because of their low densities, large home range sizes, and relatively low reproductive rate. Habitat modification from resource uses such as logging, mining, agriculture and settlement influence trapper effort by increasing access. Road construction not only makes the trapline more accessible, but weather becomes less of a factor in reducing effort. Trappers who use trucks instead of snowmobiles spend less time traveling and are able to check traps more often and in more severe weather. This increased effort may result in larger harvests (Bailey 1981).

Forest management activities that influence prey populations, disturb denning and replace important late-seral stands by early successional stages place considerable pressure on wolverine populations (Banci 1994, Lofroth 2001, Weir 2003a). Wolverines inhabiting forested areas in Montana appeared reluctant to cross large openings, often skirting the edges or running or loping across in a straight line, in contrast to the meandering travel patterns commonly displayed within timbered areas (Ingram 1973, Hornocker and Hash 1981). The biggest limiting factor in recolonization of sites by wolverines likely is the dispersal of young females, which depends greatly on connectivity (Banci 1994).

Hornocker and Hash (1981) suggested that human access on snowmobiles or all-terrain vehicles in winter and early spring could cause behavioral disturbance.

Habitat Requirements

<u>Elevations and Forest Stands</u>

General

Broadly, wolverines are restricted to boreal forests, tundra, and western mountains (Banci 1994). At landscape level, wolverine habitat is best defined in terms of adequate year-round food supplies in large, sparsely inhabited wilderness areas (Kelsall 1981). At stand level, important structural characteristics are those that favor an abundance of food (Gardner 1985, Banci 1987), and avoidance of high temperatures and of humans (Hornocker and Hash 1981).

Banci (1987) found that large individual variation in the use of forest cover types, aspect, slopes, and elevations. However, in most North American studies (Hornocker and Hash 1981, Gardner 1985, Whitman et al. 1986), and in Sweden (Haglund 1966) and Norway (Landa et al. 1998), females tend to inhabit higher elevations with early successional (alpine-type) and late successional (coniferous forests) stands in summer, during the rearing season; females in winter, and males all year-round, tend to use lower elevations with late-successsional stands.

In Montana, Hornocker and Hash (1981) reported that 70% relocations of radio-collared wolverines were in large areas of medium or scattered mature timber. Other relocations occurred in ecotonal areas, small timber pockets, and rocky, broken areas of timber benches. Areas of dense, young timber were used least. Also, males more often traveled to the extremities of their range in relatively shorter periods than did females. In Alaska, wolverines used forest types less than expected in summer, but used shrub, tundra, and rock-ice types according to availability. In winter, they did not use tundra according to availability. Forest, shrub and rock-ice areas were used as per availability (Whitman et al. 1986). Gardner (1985) also found that vegetation types associated with the higher elevations used during spring and summer months were upland shrub, tundra, and rock outcrops. During the winter, wolverines were found predominantly in spruce-dominated communities.

Omineca Region

In the Omineca region, Lofroth (2001) described wolverine habitat requirements according to three seasons:

- Season 1(late-May to mid-September): this period covers most of the summer season, and corresponds to the period when females are provisioning young; this is also the mating season for wolverine. This season encompasses den emergence by wolverine kits to the start of marmot hibernation.
- Season 2 (mid-September to mid-December): this period includes fall and early winter. During this period, ungulates (and thus carrion) are still relatively dispersed, marmots are in hibernation and foraging options are limited.

- Season 3 (mid-December to late May): this period is the primary carrion feeding season and includes the maternal denning season for adult females.

Females were found at high elevations (≥ 1500 m) during seasons 1 and 2 when they were breeding and nursing. At this time of year, they used mostly early seral stages associated with alpine ecosystems. During season 3, however, they were found at lower (900-1100 m) elevations, where they used late-seral stands in the SBS and ESSF biogeoclimatic units. Overall, females used ESSF forest stands according to their availability; these still represented > 30% of the areas used by the animals.

Males moved from low to high elevations (700-1500 m) during season 1. In seasons 2 and 3, they were at low elevations where they used late seral stands. Overall, males used less ESSF stands than expected (these represented > 40% of the area used in seasons 1 and 3), but used more SBS forest stands more than expected, particularly during fall and early winter (season 2).

Usually, subadults used lower elevations and SBS stands than females, and higher elevations and ESSF stands than males.

Lofroth (2001) found that wolverines did little use of mid-successional habitats. Also, in forested zones, wolverines did not use isolated forest patches and early seral stages. On the other hand, Lofroth's (2001) capture rates were similar in large tracts of contiguous forest and in forested corridors in locations remote from human activity. He concluded that with an increase in fragmentation, wolverine likely increased their use of forested corridors to move across the landscape.

Dens

General

Dens correspond to critical habitat features. Banci (1994) indicated that natal and maternal dens may be a limiting factor, requiring a high degree of structural diversity. They may be limiting in habitats that have been extremely modified by logging and other land-use practices. Insufficient denning habitat may serve to decrease the already low reproduction potential of wolverine.

In North America (Youngman 1975, Magoun and Copeland 1998), Norway (Myrberget 1968), Siberia (Stroganov 1969) and the former Soviet Union (Ognev 1935), dens are found under boulders and tree roots, and in accumulations of woody debris. Pulliainen (1968) and Magoun and Copeland (1998) pointed out that dens were located above treeline, under 1-5 m of snow. Most consisted of relatively long, complex snow tunnels, often associated with fallen trees or large rocks. In Norway, Landa et al. (1998) reported that dens were temporary structures dug into snow in steep, stony valley sides. Dens are abandoned in late April or early May because of snowmelt (Pulliainen 1968, Magoun 1985).

With few exceptions, wolverine reproductive dens have been located in alpine, subalpine, taiga, or tundra habitat (Haglund 1966, Myrberget 1968, Pulliainen 1968, Serebryakov 1984, Zyryanov 1989, Lee and Niptanatiak 1996, Landa et al. 1998, Magoun and Copeland 1998). Rarely have dens been reported in low-elevation, densely forested habitats, although wolverines occupy these habitats. Bjärvall (1982) located 4 reproductive dens above treeline, although 52% of the area used by the denning females was coniferous forest. The females obtained nearly all their food in the forest during the denning period, carrying food back to the alpine dens from as far away as 22 km. Magoun and Copeland (1998) believe that a critical feature of wolverine denning is dependability of deep snow throughout the denning period. At least 1 m of snow, distributed uniformly or accumulated in drifted areas, should be present by February and persist until May. Deep snow cover confers a thermoregulatory advantage to kits, which are born when winter temperatures still prevail (Pulliainen 1968, Bjärvall et al. 1978). Krebs and Lewis (1998) reported the presence of breeding females in roadless, undeveloped drainages.

Omineca Region

Lofroth (2001) reported dens on all slopes and all aspects. They were located among coarse woody debris (logs, blowdowns) in ESSFmv3, between 1550-1775 m, among structural classes 5-7, but mostly within classes 6 and 7.

<u>Comparison of Wolverine Habitat Studies</u>

Although not numerous, enough studies have been carried out in North America, and in the Scandinavian countries to identify similarities in the species habitat requirements. There is a consistent sex-related spatio-temporal use of habitats, and a need for large contiguous areas that provide cover and food throughout the year, and security and thermal habitat for denning (Table 1).

Selected Habitat Parameters

Hummel and Pettigrew (1991) pointed out "*that the same individual wolverine, as it ranges over a very large area, scavenging for carrion, will cover many different kinds of habitats, from river valleys to mountain ridges and talus slopes. Therefore, maintaining habitat for even one wolverine presents the challenge of protecting a wide diversity of habitats*". During the last decade, more information about wolverine habitat requirements has been gathered, and Lofroth's (2001) study certainly is a major step in the right direction to understand. However, quantitative information is lacking to identify suitable polygons, and develop predictive maps. Banci (1994) suggested that, until more information becomes available, habitat management prescriptions that successfully provide for the life needs of species such as American marten, fisher and lynx (*Lynx canadensis*), and their prey will also provide for the needs of wolverine at stand level. In this selection of habitat parameters for wolverine, habitat requirements of prey (i.e., old growth characteristics for caribou, early and late seral stage mosaic for moose, stand structural complexity for non-ungulate prey) have been used, as presented in Table 2.

Information contained in Table 2 is represented in Figure 1. When using Table 2 parameters to develop predictive maps, it is necessary to first identify polygons that meet stand level requirements. Suitable polygons in AT, ESSF and SBS that are contiguous should be selected (by hand and/or with a spatial optimization program) to identify >500-m-wide landscape segments similar to that of Table 2. Adjacent or properly connected landscape segments can be used to identify areas that are ≥ 100 km^2.

Table 1. Characteristics of wolverine habitats in previous studies.

Habitat Characteristics	*Studies*						
	Lofroth 2001 - Omineca	**Banci 1987 - Yukon**	**Hornocker & Hash 1981 - Montana**	**Gardner 1985, Whitman et al. 1986 - Alaska**	**Magoun and Copeland 1998 – Alaska & Idaho**	**Haglund 1966 - Sweden**	**Landa et al. 1998 - Norway**
Biogeoclimatic unit	*Females*: mostly AT & ESSF; use SBS but return to higher elevations thereafter. *Males*: AT-ESSF-SBS Subadults: AT-ESSF-SBS						
Cover type	Alpine & upland forest		Alpine (16%), dry timber (31%), wet timber (23%)	Spring-summer: alpine. Winter: spruce-dominated stands, avoid tundra.		Denning period: alpine. Winter: coniferous forests in high mountains.	
Successional type	1-3 (alpine), 6-7 (forest) Little use of mid-successional.		Avoids dense young forests.				
Canopy closure			Developed, more open than pole.				
Basal area							
Dbh							
Site type							
Understory							
Coarse woody debris	Yes						
Snags							
Impact of disturbance	Do not use isolated patches surrounded by early successional		Avoid clearcuts (also reported by Ingram 1973).				
Contiguity	≥ 100 km^2 (based on home range) Use of forested corridors.		Required for extensive movements.				

Table 1 – cont'd

Habitat Characteristics	*Studies*						
	Lofroth 2001 - Omineca	**Banci 1987- Yukon**	**Hornocker & Hash 1981- Montana**	**Gardner 1985, Whitman et al. 1986- Alaska**	**Magoun and Copeland 1998 – Alaska & Idaho**	**Haglund 1966 - Sweden**	**Landa et al. 1998 - Norway**
Elevations	Females: > 1150 in spring to fall 900-1100 m in winter Males: 700-1500 m in spring & summer 700-900 m in fall & winter	762-2088 m for all animals, 1 denning female and 1 adult male: higher elevations in summer & lower in winter	Higher elevations in summer & lower elevations in winter	Higher elevations in summer & lower elevations in winter			Higher elevations in summer & lower elevations in winter
Slopes	5-49^o		8-36%				
Special features	Marmot: alpine early seral stages, close to alpine meadows and large rocks; slopes 0-40^o.			Rock outcrops Vegetation for security.			
- den	ESSFmv3; stages 5-7, mostly 6-7; Elevations: 1550-1750 m. Subnivean, under debris; slopes 5-49^o; cold temperatures.				Alpine, subalpine, taiga, tundra; early successional stages; < 10% canopy closure; high elevations, above treeline; snow depth > 1 m, snowdrifts, fallen trees, rocky areas.	Under snowdrift and connected to rock formations.	2 in birch woodland 4 at border of birch woodland and low alpine zone 4 treeless alpine zone Subnivean in steep, stony valleys.

Table 2. Series of parameters that may be used to develop wolverine distribution predictive maps.

Parameter	***Habitat requirement***	***Justification***	***References***
		Landscape Level	
Contiguous landscape segment	≥ 100 km^2 areas consisting of ≥ 500-m-wide contiguous/connected landscape segments.	A 100 km^2 corresponds to the minimum home range size reported in previous studies.	Banci (1994) Magoun (1985) Weir (2003a)
Biogeoclimatic zones included in the landscape segment	Alpine: 15 to 50% ESSF and SBS: 50 to 85%	Alpine areas are used by females during breeding. Their relative contribution to the landscape segment will vary with topography. However, alone they are not sufficient to meet wolverine needs. These alpine areas must be connected with forested habitats.	Lofroth (2001)
Cover types	Non-forested sites in the alpine. Coniferous and coniferous-deciduous in upland and lowland forests	Non-forested sites for females during the denning season (late winter-summer) Forested sites for security and foraging (fall-winter).	Most wolverine studies.
Cover type (% of landscape segment)	The landscape segment consists of 2 distinct covers: 1) Alpine = 15-50% of segment. 2) Forested area = 50 to 85% of segment. <u>Alpine portion:</u> Meadows and rock outcrops. <u>Forested area:</u> *ESSF*: 50% of the area. ≥70% of the ESSF portion in contiguous, late-seral, spruce- or subalpine fir- dominated stands. Areas without canopy cover (< 30% of the ESSF portion): natural openings, cut blocks (immature 1 and 2 stands), etc. New cut blocks must be < 1 ha; old disturbance (pre-code) must not	The non-forested portion meets the denning and rearing needs of females. Late seral spruce and subalpine fir stands provide wildlife with complex horizontal and vertical structures, therefore with security cover and food supplies. These forests are used by mountain caribou. In order to meet caribou 's needs, openings in ESSF must be kept small.	Peek et al. (1976) Hornocker and Hash (1981) Thompson and Stewart (1997) Potvin et al. (2000) Lofroth (2001) Proulx (2001) Proulx and Kariz (2001b) Stevenson et al. (2001)

	interfere with connectivity on > 1/3 of the landscape segment width. The *SBS* is comprised of 2 sub-sections. The first sub-section is close to ESSF, and is less disturbed than the 2nd one. *SBS -1*: 50% of the total SBS area. ≥70% of SBS first subsection is in contiguous, late-seral, spruce-dominated stands, or pure pine stands with blowdown. Areas without canopy cover (< 30% of the SBS-1): natural openings, cut blocks (immature 1 and 2 stands), etc. New cut blocks must be < 1 ha; old disturbance (pre-code) must not interfere with connectivity on >1/3 of the landscape segment's width. *SBS*-2: 50% of the total SBS area. ≥50% of SBS first subsection is in contiguous, late-seral, spruce-dominated stands, or pure pine stands with blowdown. Areas without canopy cover (<50% of forested portion): natural openings, cut blocks (immature 1 and 2 stands), etc. No restriction on the impact of cut blocks on the width of landscape segment as long as a >250m-wide corridor interconnects forests bisected by cut blocks.	Openings in the SBS may be larger to provide snowshoe hare and moose with food supplies – particularly in SBS-2 where lowlands provide moose with valuable habitat year-round. In ESSF and SBS-1, the proportion of non-:forested area (< 30%) is based on wolverine radiotelemetry studies suggesting overall greater use of forests. This proportion also meets marten habitat requirements (like wolverine, this mustelid is sensitive to fragmentation) and caribou management recommendations for corridor areas. In SBS (2), an even ratio of cover and immature stands/openings (fields, marshes, etc.) is warranted to produce a mosaic of cover-food that is valuable for moose.	
Snow & Temperatures	>1 m of snow in spring in Alpine-ESSF	Snow depth required for denning. .	Hornocker and Hash (1981)

			Magoun and Copeland (1998)
Roads	≤ 0.6 km/km^2 of active roads in ESSF.	Wolverines avoid humans. Known to inhabit roadless areas. Maximum density of roads based on grizzly bear research.	Krebs and Lewis (1998) Gyug (2002) Proulx (2003)
		Stand Level	
Structural stages	Stages 1-2 in spring-summer – alpine. Stages 6-7 in winter, representing > 70% of forested area in ESSF and SBS-1. Other stage – Young (5). Avoid pole stage, as it is not used by wolverine. "Mature" stands originated from IU logging qualify as "young" if < 120 years old.	Early seral stages for denning; late-seral stages for foraging and security. Mid-seral for recruitment and connectivity for some wolverine movements. IU (industrial utilization)-logged areas (50-60 years old), although with a mature look, do not qualify as mature stands, as demonstrated with marten.	Lofroth (2001) Proulx and Kariz (2002)
Age class	Classes ≥ 7 (≥ 120 years). Class 5 may be retained to connect landscape segments and provide wolverine with dispersal cover.	Marten habitat investigations showed that age classes ≥ 7 are necessary to provide animals with adequate structural complexity (i.e., 6-7). Although wolverine may not require late seral classes to travel or hunt moose, such classes provide wolverine with many small (rodents, birds) and large (caribou) prey species. During harsh winters, these classes are also used by moose.	Peek (1997) Stevenson et al. (2001). Proulx and Kariz (2002)
Tree dbh	> 20 cm, but preferably ≥ 27.5 cm.	In the eastline of the Prince George District, trees of this size usually are associated with mature forests.	Proulx and Kariz (2001a, 2002).
Canopy closure	< 10% in alpine; ≥ 30 % in forests	Closed forest canopy accommodates late-seral species such as marten and caribou. During deep snow periods, moose also seeks such forests.	Proulx and Joyal (2001) Proulx (2001) Stevenson et al. (2001)
Basal area	0 in non-forested; ≥11 m^2/ha in mature trees in wildlife tree patches. ≥ 20 m^2/ha in mature trees in contiguous forested areas.	A basal area of ≈11m^2/ha in mature trees provides moose with sufficient cover when they are feeding in cut blocks; it also provides wolverines with hiding cover. A basal area of ≥ 20 m^2/ha in mature trees is required by prey species such as snowshoe hares, and late-seral species such as marten and caribou.	Conroy et al. (1979) Proulx and Vergara (2001) Proulx (2001) Stevenson et al. (2001)
CWD	Presence of coarse woody debris, particularly blowdowns, in the ESSF-alpine ecotonal regions.	Wolverines establish their dens under such debris. These are particularly frequent in late seral stages, and along avalanche chutes.	Previous studies on wolverine and E. Lofroth (2003,pers. commun.)

Rock outcrops	Presence in alpine regions; particularly in small valleys.	Used by wolverines for denning; used by marmots.	Previous studies on wolverine. Lofroth (2001)
Snags	> 19 snags (> 20 cm dbh)/ha	Presence of snags is related to late-seral stages, greater structural complexity, and generally greater biodiversity.	Thomas (1979) Proulx (2001)
Understory	> 20% in forested sites.	Used by prey and late-seral species such as marten.	Keith and Surrendi (1971) Proulx (2001)
Food supplies	The selection of the landscape segment must take into consideration the presence of prey – Marmot, caribou and/or goat, ground-nesting birds during denning period; moose and carrion during winter.	Although this criterion is not part of forest inventory datasets, when selecting landscape segments to identify ≥ 100 km^2 areas, such information must be taken into consideration. Mountain goats have been found to be an important food item in the Columbia Mountains (E. Lofroth, 2003, pers. commun.). Although not present in Canfor's Tree Farm Licence # 30, they inhabit adjacent regions.	Previous studies Proulx (2000)

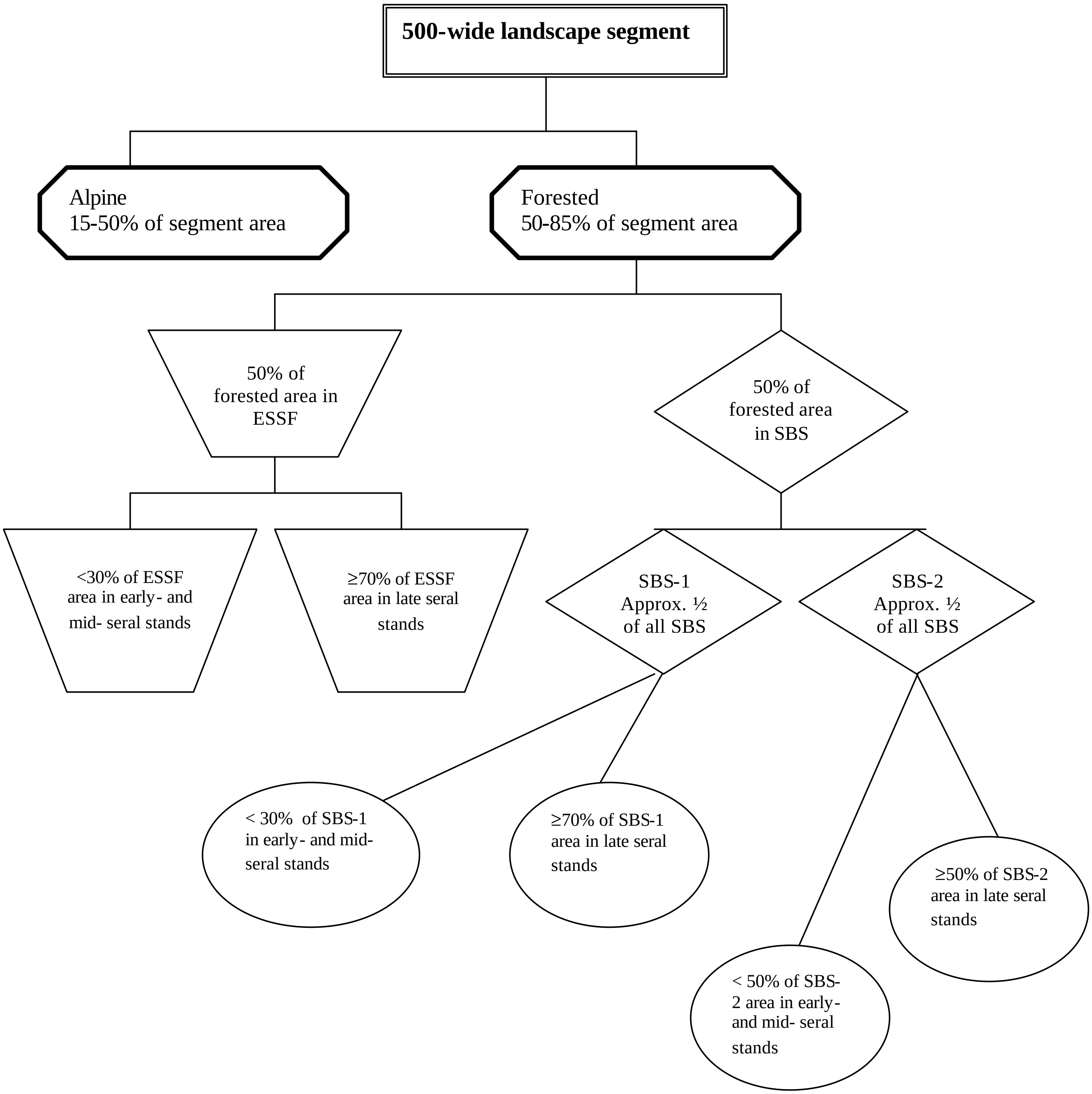

Figure 1. Creation of a wolverine landscape segment.

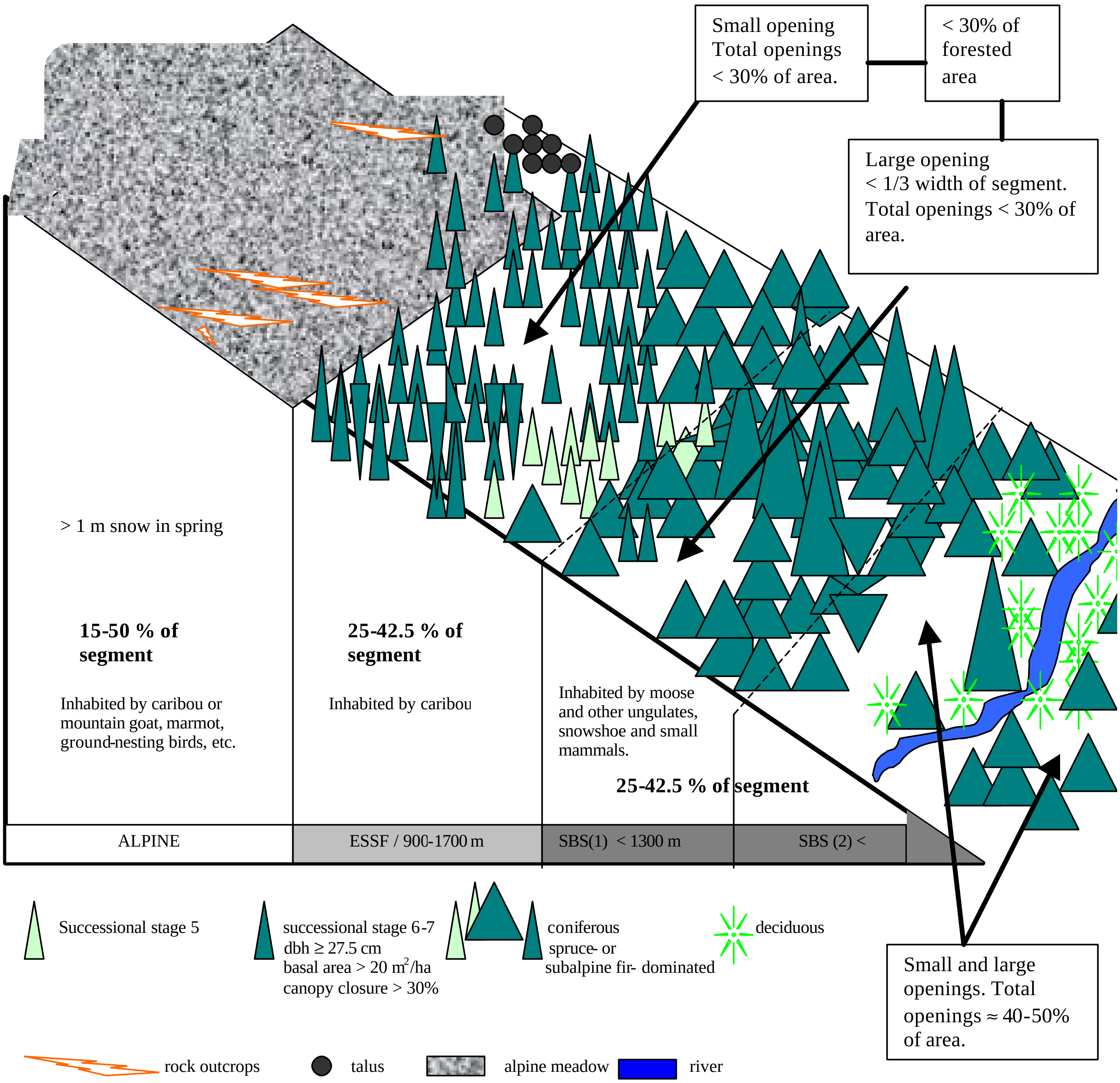

Figure 2. Example of an optimal landscape segment (³ 100 km^2) for wolverine (£ 0.6 km/km^2 of active roads in ESSF).

FISHER

Species Account

Description

Long and slender body, dense dark brown to black fur coat, bushy tail, pointed face, rounded ears, strong short legs. Males (2.7-5.4 kg) are twice larger than females (1.4-3.2 kg) (Proulx et al. 2002).

Status

The species is blue-listed in British Columbia. Weir (2003b) estimated a density of 1 fisher/146 km^2. Fisher populations are managed as Class 2 furbearers, i.e., that move among traplines, are vulnerable to overtrapping, and generally not found in manageable numbers within a single registered trapline.

Distribution

Fishers are widely distributed throughout much of central British Columbia. They are present throughout the Prince George Region, predominantly in ICH and SBS Biogeoclimatic units (Proulx and Cole 1996, Proulx and Kariz 2001a, 2002).

Population Dynamics

Fishers breed between late March and April but embryos do not implant in the uterus until January-February. They give birth in late winter. Mean fecundity (determined with counts of *corpora lutea*) varies with age (e.g., in Ontario, 3.5-7.5-year-old females had larger litters than others), populations (e.g., 3 *c.l.*/female in a recovering population vs. 3.5 *c.l.*/female in an increasing population in Ontario), and years (e.g., a population mean fecundity in Ontario ranged from 3 to 3.5 over 12 years) (Douglas and Strickland 1987, Frost and Krohn 1997). In British Columbia, during the early 1990s' fur-trapping seasons, the mean maximum number of kits/female was 2.3 (Weir 2003b).

Trapping is a major mortality factor (Krohn et al. 1994, Banci and Proulx 1999). Possible predators are large canids and felids, and birds of prey (Douglas and Strickland 1987, Proulx et al. 1994). Fishers are also killed by conspecifics (Buck et al. 1983, Proulx et al. 1994, Weir 2000). Death due to starvation was also reported in north-central British Columbia (Weir 2000).

Home Ranges

Home ranges of adult fishers vary regionally according to habitat quality, and seasonally according to animal activity (e.g., breeding, non-breeding, dispersal) (Johnson 1984, Badry et al. 1994). The home range of adult males (18-79 km^2) is usually several times larger than that of females (4-32 km^2) (Powell and Zielinski 1994). In central British Columbia, Weir et al. (2003a) reported an annual home range of 34 km^2 for females, and 137 km^2 for males. Intersexual home range overlap occurs.

Fisher travel is hindered by soft snow. During periods of little snow depth or of heavy crust conditions, fishers travel widely. However, when deep, soft snow is present, fishers select coniferous areas where travel is easier due to lesser snow depths (Leonard 1980, Raine 1983, Johnson 1984). In California, Krohn et al. (1997) suggested that areas occupied by American marten were closely associated with forested areas with the deepest snow (> 23 cm snowfall per winter month), areas occupied predominantly by fishers were forested areas with low monthly snowfall (< 13 cm), and overlap zones with both species were in forested areas of intermediate monthly snowfalls (≥ 13 to 23 cm). Krohn et al. (1995, 2003) also suggested similar fisher-snow relationships in Maine. Weir (1995) suggested that fishers in the East Cariboo region of central British Columbia used patches with large trees because the overstory closure afforded by these trees may have increased snow interception.

Food Habits

Fishers are opportunistic, feeding on small mammals and birds, snowshoe hares, porcupines (*Ertethizon dorsatum*), berries, and carrion (Powell and Zielinski 1994, Proulx, pers. observ.). In British Columbia, Weir (1995) found that snowshoe hares were the single most commonly occurring prey, followed in frequency by red squirrel, southern red-backed vole (*Clethrionomys gapperi*), and porcupine. Female fishers exploited the small mammal food group more often than did males, and males consumed other mustelids more than did females.

Main prey species have the following habitat requirements:

Snowshoe hare: see the *Wolverine* section.

Red squirrel (*Tamiasciurus hudsonicus*): occurs mainly in coniferous forests, although it also inhabits mixed and deciduous forests (Kemp and Keith 1970, Rusch and Reeder 1978, Sullivan and Moses 1986). In the boreal forest, red squirrels show an affinity for multi-storied stands containing trees of 30-35 cm dbh in dense groups (Vahle and Patton 1983). Since they construct nests in trees whose crowns are at least partially surrounded by or frequently interlocking with those of other trees (Rothwell 1979), mature and old forests with a canopy closure > 30% provide them with proper overhead cover. Large standing snags and fallen trees are important sites for cone storage. The frequent occurrence of middens accumulated around large diameter trees, logs and snags indicates red squirrels prefer these structures for use as feeding stations and caching sites (Vahle and Patton 1983).

Red-backed vole: usually inhabit mesic coniferous forests (Tevis 1956, Nordyke and Buskirk 1991), and mixed coniferous-deciduous and deciduous stands (Proulx, unpubl. data), where they associate closely with large-diameter logs (Hayes and Cross 1987) and understory plant cover (Nordyke and Buskirk 1991).

Threats

Trapping has the potential to affect populations of fishers by changing mortality rates and the reproductive potential of the population (Badry 2003). Banci and Proulx (1999) identified fisher populations as having low to intermediate resiliency to trapping pressure, which means that fisher populations generally have a moderate capability to recover from a reduction in numbers.

In an extensive review of the worldwide distribution of *Martes* species, Proulx et al. (2003) identified loss of forested habitat at from human development as the main long-term threat to fisher populations throughout its range. Since fishers have large spatial requirements, the long-term maintenance of extensive forestlands will be the major conservation challenge (Proulx et al. 2003). Forest management activities that influence prey populations, disturb denning and replace important late-seral stands by early successional stages place considerable pressure on fisher populations (Badry 2003).

Habitat Requirements

Elevations and Forest Stands

General

Fishers have been reported to inhabit landscapes dominated by mature coniferous (deVos 1952, Coulter 1966) and mixed coniferous-deciduous forests (Coulter 1966, Kelly 1977, Powell 1977). Independent of the forest region studied, fishers inhabit areas with a multi-storied and continuous overhead cover, and a complex ground structure with coarse woody debris and a well-developed understory (Proulx and Banci 2003). In Wisconsin, in winter, Gilbert et al. (1997) found that fisher rest sites were underground, under woody material or in standing trees. There was no clear preference demonstrated for any type of rest site. In the western provinces and the Rocky Mountains, fishers appear to prefer late-successional coniferous forests and riparian habitats, particularly at elevations of < 1000 m (Raphael 1988, Rosenberg and Raphael 1986, Jones 1991, Aubry and Houston 1992, Heinemeyer 1993, Jones and Garton 1994). However, they are known to use mid-successional, second growth, and hardwood forests throughout their ranges (Jones 1991, Roy 1991, Proulx and Banci 2003). Badry et al. (1997) found that fishers could survive in the aspen parkland region of Alberta, where snow accumulations are substantially less than in the boreal forest; animals used forests with a deciduous cover and dense understory vegetation (> 25 woody stems/m^2).

Because the rate at which transients are able to successfully navigate the landscape and establish home ranges may be more important than natality ranges in determining population persistence within the landscape (Fahrig and Paloheimo 1988), connectivity within a landscape must be maintained. This is particularly true for fishers, which do not move easily in deep soft snow, and may be preyed upon by various predators once in the open (Proulx et al. 1994). Minimum stand size has been estimated at 40 ha by Badry et al. (1997).

Central British Columbia

Few studies have been carried out in central British Columbia. Two studies in the SBS (east Cariboo and Williston) provided significant information on central B.C. fisher populations (Weir 2003b). However, several local inventories also resulted in a better understanding of winter habitat use by fisher (e.g., Proulx and Cole 1996, Proulx and Kariz 2001a,c, 2002).

Fisher habitat requirements may be classified according to three seasons:

- Season 1 (late March-June) – in the Williston region, Weir (2000) reported that the mean date of parturition of radio-tagged fishers was 6 April. On the basis of Paragi et al. (1996) who found that Maine female fishers discontinued using maternal dens 71 days following parturition, the dens are likely abandoned in June.

- Season 2 (July-November) – in summer and early fall, fishers are known to use a variety of habitats of various composition, structure and age throughout their range (Powell and Zielinski 1994).
- Season 3 – (December-March) – during winter, fisher are found in >5 age class coniferous stands (Proulx and Kariz 2001a,c, 2002).

Seasons 1 and 3 are critical for fisher. During Season 1, nutritive requirements are high. During Period 3, energetic requirements are high. This is in agreement with Allen (1983) who considers winter and early spring habitat to be critical for fishers. During both periods, fishers are known to use habitats at elevations < 1000 m (Proulx and Cole 1996, Proulx and Kariz 2001a,c, 2002, Weir 2003b). In the Prince George District, such elevations correspond to SBS and ICH biogeoclimatic units where precipitations are lower and winter temperatures are warmer than at higher elevations, in the ESSF (Table 3). At lower elevations, fishers inhabit riparian stands, which are particularly rich in large denning trees (Weir 2003b - see dens below).

Table 3. Comparison of SBS, ICH and ESSF environmental conditions.

Biogeoclimatic Unit	Elevations	Temperatures	Precipitations	Percentage in snow	References
SBS	Valley bottoms to 1100-1300 m	< 0^{o}C for 4-5 months > 10^{o}C for 2-5 months	440-900 mm	25-50%	Meidinger et al. 1991
ICH	100-1000 m	< 0^{o}C for 2-5 months > 10^{o}C for 3-5 months	500-1200 mm	25-50%	Ketcheson et al. 1991
ESSF	900-1700 m	< 0^{o}C for 5-7 months > 10^{o}C for 2 months	400-2200 mm	50-70%	Coupé et al. 1991

In their SBS study area, Weir and Harestad (2003) found that fishers selected stand classes with moderate values of most structural attributes. Fishers primarily avoided extreme stand classes (i.e., those stands classified as having either extremely high or low values of particular structural attributes). However, fishers exhibited patch-scale selectivity most frequently when using stands with extremes of structural attributes. For example, when fishers used stands with no structure recorded at random points, they selected patches within these stands that had significant more structure. Fishers selected patches with significantly less structure in stands that had extremely high values of coniferous canopy, high shrub, and low shrub closures. Fishers also selected patches in stands with high stocking densities of trees > 40 cm dbh and trees with rust brooms. Weir and Harestad (2003) did not detect fishers exhibiting selection for stands with extremely high volumes of coarse woody debris during summer or CWD > 20 cm diameter in winter. Fishers avoided habitats without overstory or shrub cover.

Winter tracking data are useful to identify habitats used by fishers (Proulx and Banci 2003). In December 2000, in Canfor's Tree Farm Licence # 30, Proulx and Kariz

(2001a) reported that the great majority (88%) of 125 recorded fisher tracks were in stands where structural complexity was present. Tracks were more abundant than expected in young coniferous stands, and less abundant in forests with deciduous cover. In December 2001 and January 2002, Proulx and Kariz (2002) recorded 44 and 33 fisher tracks in SBS and ICH zones, respectively. Fisher tracks were distributed according to the availability of stands. In January 2001, in the SBS biogeoclimatic unit of the Morice Forest District, Proulx and Verbisky (2001) recorded 13 fisher tracks within a movement corridor network crossing a landscape dominated by immature stands. All tracks were in mid- and late-successional stands.

Large pieces of CWD may be important habitat elements for fishers during long periods of extremely low temperatures because they likely provide a more favorable thermal microenvironment than that found at other types of rest structures (e.g., rust brooms, tree branches, cavity structures) (Weir et al. 2003b). Coarse woody debris rest structures were usually comprised of a single large > 35 cm diameter piece of debris, but occasionally involved several pieces of smaller diameter logging residue.

Denning Sites

General

Natal (i.e., whelping) and maternal (i.e., rearing) dens of fishers are typically found in cavities, primarily in deciduous trees (Powell 1993). Leonard (1980) hypothesized that dens were situated in tree cavities because they provide thermal benefits and security from other carnivores. Female fishers use between 1 and 5 maternal dens following abandonment of the original natal den (Paragi et al. 1996).

In south-western Oregon, fishers use cavities and witches brooms in coniferous trees and logs as natal and maternal dens (Aubry et al. 2001). In Wisconsin, most (5/6) dens were in standing live trees of ≥ 52 cm dbh (Gilbert et al. 1997). In north-central Massachusetts and southwestern New Hampshire, Powell et al. (1997) found that the majority of 52 maternal dens were located in softwood overstory and less often in hardwood overstory. Dens were found 1.9-15.4 m above ground, in tress with a dbh ranging from 30 to 104 cm.

Central British Columbia

Weir and Harestad (2003) observed 3 female fishers using 5 natal or maternal dens during two whelping seasons. Females established natal and maternal dens exclusively in branch-hole cavities in large-diameter, declining (i.e., alive, but showing signs of decay) black cottonwood trees. These trees were significantly larger than other black cottonwood trees within natal and maternal den patches. The mean height of natal and maternal den cavities was 25.9 m. The cottonwood trees used by fishers in British Columbia are atypically large. Such trees are rare across the landscape and may be an important component in the selection of a home range by female fishers (Weir 1995).

Comparison of Fisher Habitat Studies

Although fisher's distribution range covers a diversity of ecoregions across the continent (Proulx et al. 2003), similarities exist among populations (Table 4).

Selected Habitat Parameters

Selectivity for resources by fishers appears to be compensatory across spatial scales. That is, when using sub-marginal habitat at large scales, fishers appear to be able to select habitat at smaller spatial scales within the otherwise unsuitable habitat, and thus meet their resource needs (Weir 2003b, Weir and Harestad 2003). For example, when fishers use stands with low overhead cover, they use remaining patches of trees that provide overhead cover within the otherwise poor matrix. Conversely, fishers appear to select atypical elements within patches to fulfill their most specific resource requirements. However, as pointed out by Weir (2003b), this multi-scaled approach to habitat management, although flexible, must be applied prudently. Caution should be used with its application because all of the habitat requirements of fishers cannot likely be maintained solely at small patch scales. It is unlikely that the cumulative degradation of larger scale habitats (e.g., landscape, stands) can be totally compensated for at increasingly smaller scales. For this reason, in this project, the selection of polygons and landscape segments on the basis of 2nd (home range) and 3rd (stand) orders is more appropriate. However, knowing that fishers target specific elements within stands allow one to better describe stand characteristics to meet the species needs. Also, although valuable information on fisher ecological needs has been gathered during the last decade, there are still uncertainties about the needs of the species at landscape level. Proulx and Banci (2003) pointed out that American marten, and fisher to a lesser extent (because the species is more generalist than marten in its use of habitats), can be associated with stands where structural complexity has been initiated. Fishers are less likely to use structural classes 1-4. Also, Proulx and Verbisky (2001) showed that, in winter in a highly fragmented landscape, fishers restricted their activities to forested corridors. The overhead requirements of fisher are similar to those of the American marten. This allows one to use some of marten's management strategies (Proulx 2001) to complete the selection of parameters for predictive distribution maps.

Information contained in Table 5 is represented in Figure 3. When using Table 5 parameters to develop predictive maps, it is necessary to first identify polygons that meet stand level requirements. Queries need to distinguish between late-seral polygons with and without potential denning trees. The presence of potential denning sites, particularly atypical large declining cottonwoods, should be the focal point of the selection of polygons to create ≥ 30 km^2 landscape sections.

Table 4. Characteristics of fisher habitats in previous studies.

Habitat Characteristics	*Studies/Reviews*									
	Weir's studies[2] (Williams Lake and Williston areas)	**Proulx and Banci 2003**	**Proulx and Cole 1996 (Robson Valley)**	**Proulx and Kariz 2001a, 2002 (TFL#30 and Prince George District eastline)**	**Proulx and Verbisky 2001 (Parrot Lake area-Morice District)**	**Leonard 1980 (Manitoba)**	**Paragi et al. 1996, Powell et al. 1997, Gilbert et al. 1997 (eastern and Midwest USA)**	**Badry et al. 1994 (Alberta aspen parkland)**	**Jones 1991, Jones and Garton 1994 (north-central Idaho)**	**Thomasma et al. 1994 (Michigan)**
Biogeoclimatic unit	SBS		ICHwk3	SBS & ICH						
Cover type	Coniferous and coniferous-deciduous, with atypical large deciduous trees.	Coniferous and coniferous-deciduous	Coniferous and coniferous-deciduous. Dominant species: Western Redcedar (*Thuja plicata*) and Western Hemlock (*Tsuga heterophylla*)					Two-storied deciduous stand.		
Structural stages	Preferably 6 and 7	≥ 4 Did not use sites without structural complexity or canopy cover. Used pole, but mostly young, mature and old.		≥ 5	≥ 5				Greater than expected use of mature forests in summer, and young forests in winter. Non use of nonforest or pole-sapling successional stages in winter.	

[2] Includes Weir (1995), Weir 's (2003b) draft status report, Weir and Harestad (2003), and Weir et al. (2003 a,c).

Table 4, cont'd

Habitat Characteristics	*Studies/Reviews*									
	Weir's studies[3] (Williams Lake and Williston areas)	**Proulx and Banci 2003**	**Proulx and Cole 1996 (Robson Valley)**	**Proulx and Kariz 2001a, 2002 (TFL#30 and Prince George District eastline)**	**Proulx and Verbisky 2001 (Parrot Lake area-Morice District)**	**Leonard 1980 (Manitoba)**	**Paragi et al. 1996, Powell et al. 1997, Gilbert et al. 1997 (eastern and Midwest USA)**	**Badry et al. 1994 (Alberta aspen parkland)**	**Jones 1991, Jones and Garton 1994 (north-central Idaho)**	**Thomasma et al. 1994 (Michigan)**
Canopy closure	Coniferous: 21-60% Deciduous: 21-40%		> 45%	> 30%				40 %	40%	25-50 %
Basal area				≥ 20.5 m^2/ha in trees with > 27.5 cm dbh						
Stocking of trees > 40 cm dbh (stems/ha)	1-100									
Dbh	>40 cm – resting; > 88 cm – denning in declining cottonwoods or cottonwoods with cavities; > 65.9 cm - single pieces of large elevated CWD; > 44.2 cm – aspen with cavities.			> 27.5 cm				65 cm (deciduous)	34-47 cm	27 cm

3 Includes Weir (1995), Weir 's (2003b) draft status report, Weir and Harestad (2003), and Weir et al. (2003 a,c).

Table 4, cont'd

Habitat Characteristics	*Studies/Reviews*									
	Weir's studies[4] (Williams Lake and Williston areas)	**Proulx and Banci 2003**	**Proulx and Cole 1996 (Robson Valley)**	**Proulx and Kariz 2001a, 2002 (TFL#30 and Prince George District eastline)**	**Proulx and Verbisky 2001 (Parrot Lake area-Morice District)**	**Leonard 1980 (Manitoba)**	**Paragi et al. 1996, Powell et al. 1997, Gilbert et al. 1997 (eastern and Midwest USA)**	**Badry et al. 1994 (Alberta aspen parkland)**	**Jones 1991, Jones and Garton 1994 (north-central Idaho)**	**Thomasma et al. 1994 (Michigan)**
Site type				Circum mesic						
Understory	High shrub (2-10 m) – 41-60% Low shrub (0.15-2 m) < 80%.							25 stems/m^2		
Coarse woody debris	Yes 200 m^3/ha							28 cm (decay class 3)	14-34.3 cm	
Snags	Yes								24-34 cm	
Impact of disturbance	Landscape units in which mature and old seral stages are disturbed in patches smaller than approximately 50 ha throughout the unit will not likely support fisher populations.							Patches > 40 ha	Less use of large isolated stands	

[4] Includes Weir (1995), Weir 's (2003b) draft status report, Weir and Harestad (2003), and Weir et al. (2003 a,c).

Table 4, cont'd

Habitat Characteristics	*Studies/Reviews*									
	Weir's studies[5] (Williams Lake and Williston areas)	**Proulx and Banci 2003**	**Proulx and Cole 1996 (Robson Valley)**	**Proulx and Kariz 2001a, 2002 (TFL#30 and Prince George District eastline)**	**Proulx and Verbisky 2001 (Parrot Lake area-Morice District)**	**Leonard 1980 (Manitoba)**	**Paragi et al. 1996, Powell et al. 1997, Gilbert et al. 1997 (eastern and Midwest USA)**	**Badry et al. 1994 (Alberta aspen parkland)**	**Jones 1991, Jones and Garton 1994 (north-central Idaho)**	**Thomasma et al. 1994 (Michigan)**
Contiguity	The mature and old seral stage objectives for intermediate biodiversity emphasis (≥25% of landscape) may be sufficient to support a viable population of fishers if its distribution is contiguous and concentrated in one area of the landscape unit. The mature and old seral stage retention for the higher biodiversity emphasis option is sufficient, if suitable stands are retained and connectivity is maintained through riparian corridors or contiguous tracts of late seral stages.				Use of ≥ 250 m-wide corridors.				Prefer forested riparian areas for traveling.	
Elevations			≤ 750 m							

[5] Includes Weir (1995), Weir 's (2003b) draft status report, Weir and Harestad (2003), and Weir et al. (2003 a,c).

Table 4, cont'd

Habitat Characteristics	***Studies/Reviews***									
	Weir's studies[6] (Williams Lake and Williston areas)	**Proulx and Banci 2003**	**Proulx and Cole 1996 (Robson Valley)**	**Proulx and Kariz 2001a, 2002 (TFL#30 and Prince George District eastline)**	**Proulx and Verbisky 2001 (Parrot Lake area-Morice District)**	**Leonard 1980 (Manitoba)**	**Paragi et al. 1996, Powell et al. 1997, Gilbert et al. 1997 (eastern and Midwest USA)**	**Badry et al. 1994 (Alberta aspen parkland)**	**Jones 1991, Jones and Garton 1994 (north-central Idaho)**	**Thomasma et al. 1994 (Michigan)**
Slopes										
Special features	Rust brooms as resting sites.								Prefer forested riparian areas for resting. Also, these areas are richer in snowshoe hares and red-backed voles.	
dens	Cottonwoods > 88 cm dbh. Trees with heart rot and a bole diameter greater than 54 cm at 5 m above ground. Trees > 70 years old.					Large deciduous trees with cavities	Hardwood trees. Median diameters: 45-66 cm.		Prefer large-diameter Engelmann spruce trees and hollow Grand Fir (*Abies grandis*) logs as resting sites.	

[6] Includes Weir (1995), Weir 's (2003b) draft status report, Weir and Harestad (2003), and Weir et al. (2003 a,c).

Table 5. Series of parameters that may be used to develop fisher distribution predictive maps.

Parameter	***Habitat requirement***	***Justification***	***References***
		Landscape Level	
Minimum patch size	> 40 ha	Minimum patches reported in previous studies to provide fisher with proper cover for security and hunting.	Badry et al. (1997) Weir et al. (2002)
Biogeoclimatic zones included in the landscape segment	SBS, ICH	Fisher movements are greatly limited by snow conditions. SBS and ICH include lowlands and significant riparian sites, with snow accumulations lower than those recorded in ESSF.	Previous studies in British Columbia B.C. Government (1995)
Cover types	Coniferous and coniferous-deciduous for all seasons. Possibly deciduous during the breeding and summer seasons.	Coniferous and mixed stands intercept snow. Deciduous stands (either pure or small patches within coniferous stands) with atypical large cottonwoods and aspens may provide fishers with denning sites.	Most winter studies in western Canada, and Weir (2003b).
Polygon amalgamation	Suitable > 40 ha patches should be amalgamated to produce contiguous landscape sections that are ≥ 30 km^2. Patches must be approximately 600 m wide, < 200 m apart, or be connected by ≥ 250-m-wide forested corridors (structural class ≥ 4).	The ≥ 30 km^2 amalgamated area corresponds to the average minimum home range expected for the areas.	Weir (2003b)
Snow	Relatively low accumulations characteristic of SBS and ICH	Snow may interfere with fisher activities.	Krohn et al. (1997, 2003)
Roads	-	Road management relates mainly to trappers' activities along accessible areas.	Banci and Proulx (1999)
		Stand Level	
Patch structure	- ≥ 50% of patch in late seral stands with structural class 6 or 7 (some with atypical large trees for denning) - <50 % of patch in Stages 1 to 5.	Fisher is more flexible than marten, which requires landscapes with at least 70% forest cover. The minimum amount of late seral stages recommended here exceeds guidelines for landscapes with high biodiversity emphasis.	

Late seral stand composition	▪ Coniferous or coniferous-deciduous stands. Some with atypical large deciduous or Douglas-fir (*Pseudotsuga menziesii*) or spruce, for denning; such stands often are part of riparian forests, and include: - declining cottonwoods with > 88 cm dbh (> 70 years old); and/or - aspen with > 44 cm dbh, and/or - Douglas-fir or spruce with > 60 cm dbh ▪ Deciduous cottonwood stands	Late seral stands are important for fisher in winter (to intercept snow), for movements within the home range, or during dispersal.	Proulx and Kariz (2001a, 2002) Proulx and Verbisky (2001) Proulx and Banci (2003) Weir (2003b) Weir and Harestad (2003)
Structural stages	Stages 6-7 "Mature" stands originated from IU logging qualify as stage 5 if they are < 120 years	Structure classes 6 and 7 are structurally complex and provide fisher and its prey with optimal environmental conditions.	Proulx (2001) Proulx and Kariz (2001a, 2002)
Age class	Late seral stands (50% of patch) : Classes ≥ 7 (≥ 120 years). Remaining 50% of patch: Classes 5-6 for dispersal cover, and younger classes for food.	Marten habitat investigations showed that age classes ≥ 7 are necessary to provide animals with adequate structural complexity (i.e., 6-7). Although fisher may not require late seral classes to travel or hunt snowshoe hares, > 120 years-old stands provide fisher with suitable resting and whelping sites, and abundant prey (e.g., small mammals, hares, ground-nesting birds, etc.). Fisher is also known as an ecotonal species feeding on small mammals inhabiting forest edges and berries.	Proulx (2001) Weir (2003b)
Tree dbh	≥ 27.5 cm for late seral stands. The stand should encompass some trees with > 40 cm dbh to provide fishers with resting sites. Specific minimum dbh have been identified for den trees (see above).	In the eastline of the Prince George District, trees of this size usually are associated with mature forests.	Proulx and Kariz (2001a, 2002).

Canopy closure	30-60%	These canopies provide environmental conditions that are favorable to fishers and their prey. Also provide for adequate snow interception.	Most previous studies Proulx and Vergara (2001)
Basal area	Within contiguous forested areas, ≥ 20 m^2/ha in mature trees	≥ 20 m^2/ha in mature trees is required by prey species such as snowshoe hares, and late-seral species such as marten and red-backed voles.	Conroy et al. (1979) Proulx and Vergara (2001) Proulx (2001)
CWD	>20 cm	The larger, the better. However, the presence of > 20 cm diameter debris is usually associated with late seral stands.	Proulx (2001) Proulx and Vergara (2001) Weir (2003b)
Rock outcrops	-	-	
Snags	> 19 snags (> 20 cm dbh)/ha.	Presence of snags is related to late-seral stages, greater structural complexity, and generally greater biodiversity.	Thomas (1979) Proulx (2001)
Understory	> 20% shrub cover.	Used by prey like snowshoe hare.	Keith and Surrendi (1971) Proulx (2001) Weir and Harestad (2003)
Food supplies	The selection of the landscape segment must take into consideration the presence of prey – snowshoe hare, red squirrel, voles, porcupine, and ground-nesting birds.	< 40 ha patches may not support viable prey populations.	Previous studies on the biology of the prey species. Proulx and Vergara (2001)

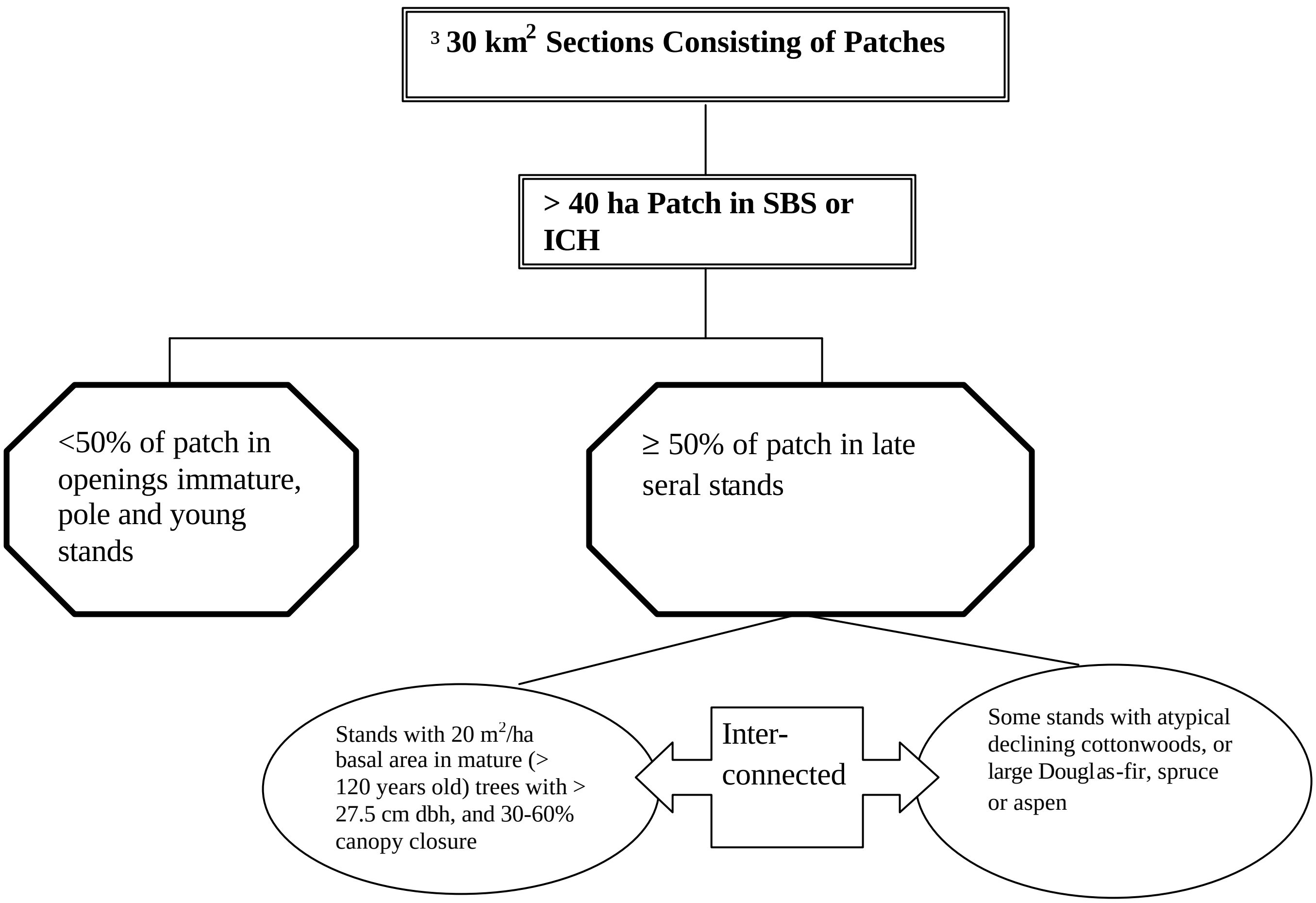

Figure 3. Creation of a fisher landscape segment.

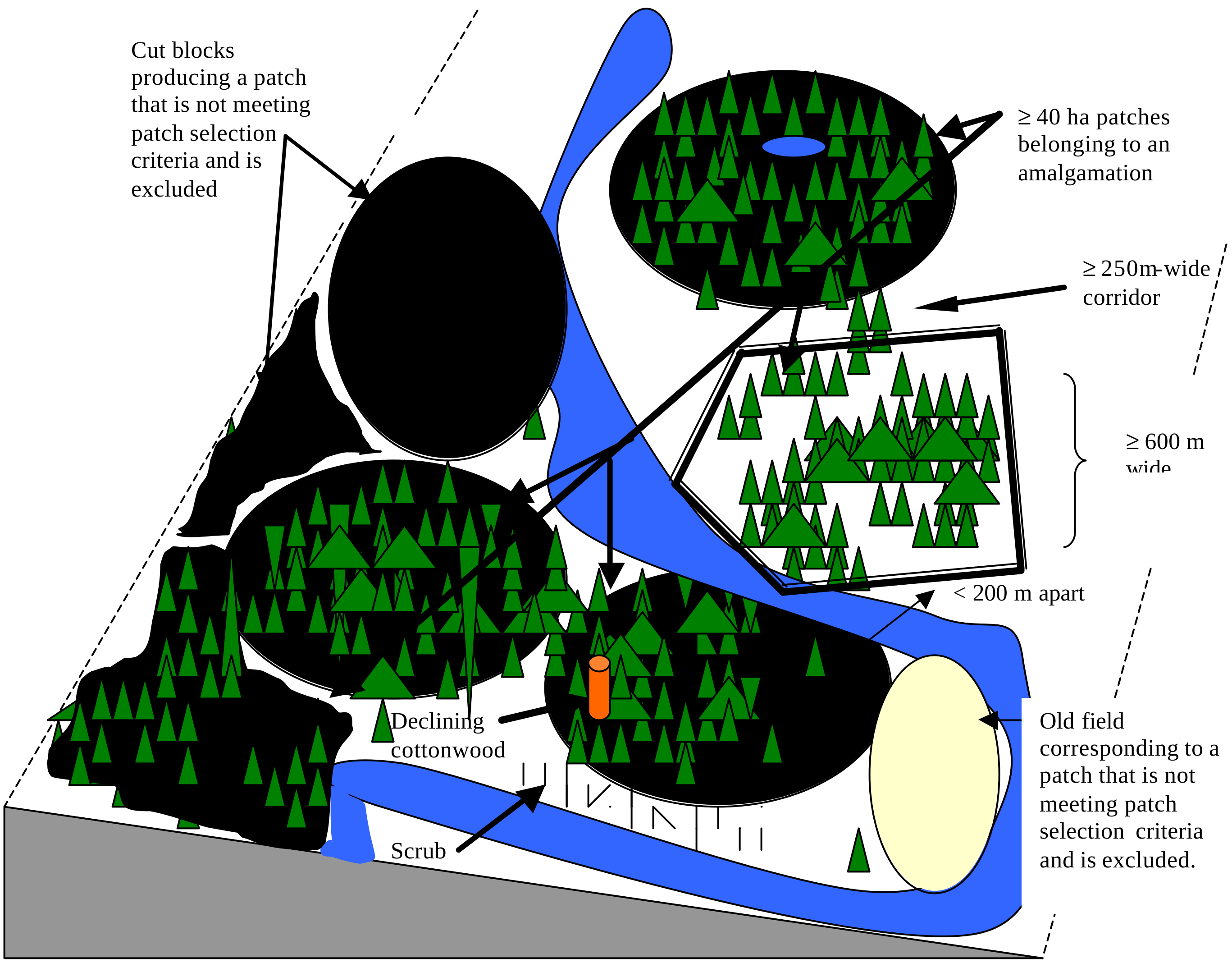

Figure 4. Example of an optimal landscape segment (≥ 30 km²) for fisher.

GRIZZLY BEAR

Species Account

Description

Sturdy, plantigrade animal with prominent shoulder hump (muscle mass covered with long guard hairs), and massive head with upturned muzzle (dishface profile), short round ears, and a slight ruff around the back portion. Color ranges from pale yellowish brown to dark brown, nearly black. Silvery white tips on hairs give a frosted or grizzly effect. Very long claws (front paw : 3.5-10 cm; back paw : 1.5-4.5 cm). Total length: 1.8-2.1 m. Weight – Males: 250-350 kg – Females: 100-175 kg (Proulx et al. 2002).

Status

The grizzly is a blue listed species in British Columbia. There is presently a Limited Entry Hunt in 18 of the Omineca/Peace (Region 7) Management Units. Based on a population study in 2001, Mowat et al (2001) suggested that these current harvest levels could be supported outside the area of the Hart Mountain range.

Distribution

Grizzly are presently distributed throughout all B.C. Forest Districts with the exception of Duncan, Port Alberni, Queen Charlotte districts and only in the mainland portions of the Campbell River and Port McNeil districts (Proulx et al. 2003). They are considered extirpated (from > 75% by area) in Penticton, Kamloops, 100 Mile and Williams Lake Districts. Grizzly bears are found throughout the Prince George Forest Region, particularly in mountainous and remote areas. In this region they are able to inhabit all Biogeoclimatic units(Gyug 2002, Proulx et al. 2002).

Population Dynamics

Grizzly breed from late April to the end of June but due to delayed implantation, do not give birth until January to March. Mean litter size ranges from 1.6 to 2.5 cubs with a delay of 2 to 4.3 years between births (Banci 1991). The average age for first litters is 6 years, and the cubs usually stay with the mother until their 2^{nd} spring.

The average lifespan of grizzly bears ranges from 20-30 years. Predation by mature males on first year cubs seems to account for a certain degree of population control. Other mortality factors include; hunting, poaching, accidents (vehicle, railroad, etc.), human protection measures, and malnutrition. Malnutrition is generally only associated with very young cubs, and tends to be a result of poor maternal nutrition prior to denning (Gyug 2002).

Home Ranges

Various factors affect the size, shape, and degree of overlap of home ranges: age (Pearson 1975), sex (1975, Schallenberg and Jonkel 1980), geographic location (LeFranc et al. 1987), topography (Pearson 1975, Schallenberg and Jonkel 1980), location of food sources (Pearson 1975), spring-fall critical ranges, denning sites (Craighead and Craighead 1972), individual variation, cultural transmission, human influences, and bear density (Jonkel 1987). The effects of all these variables on central British Columbia grizzly bear home ranges are not known. However, it is known that home range sizes vary depending on whether the grizzlies inhabit interior mountain or interior plateau landscapes:

- Interior mountain grizzly: females – 27-103 km^2, males – 166-187 km^2 (Mowat et al. 2002)
- Interior plateau grizzly: females – 191-222 km^2, males – 352-804 km^2 (Mowat et al. 2002, Ciarniello et al. 2002)

In the Omineca area, the mountain bears had much smaller ranges than did the plateau bears. Also, the males generally had much larger ranges than did female bears. Home range fidelity may be quite strong as habitat selection and foraging patterns are believed to be learned activities. This tends to be true of females more than of males and may also result in low dispersal capabilities (Gyug 2002). It has been suggested that human impact may outweigh habitat quality in predicting bear densities in the Herrick area of the Prince George Forest District (Mowat et al. 2002).

Food Habits

General

Grizzly bears are omnivorous, although they will prey on other species and scavenge if the opportunity arises. The main food types that have been identified include (but are not limited to); roots and corms, green vegetation, small and large mammals (especially ungulate calves and rodents), berries, carrion, and fish if available.

Omineca

Food habits of interior mountain grizzly tend to be seasonal in nature as they must accommodate snowmelt and green-up, berry ripening, and snowfall during their three active feeding seasons. After den emergence, grizzly bears tend to move towards lower elevations where new spring vegetation is just starting to emerge. Moose also tend to calve in these areas, which allows the grizzly access to high protein sources when their fat and energy stores may be particularly low.

As snowmelt moves up the valleys and into the mountains, so do the grizzlies, essentially following the emergent vegetation until they reach the mountain meadows. Most mountain bears remain at high elevations, grazing throughout July and into August, when they again move down to take advantage of ripening berry crops (Ciarniello et al. 2001).

Fall food sources include berries, small mammals, ground squirrels and grubs (Ciarniello et al. 2001). In areas such as the upper Fraser River basin, where there are fall salmon runs, this appears to be an important food source (Mowat et al. 2002).

Threats

The primary population threat is hunting (Banci 1991), followed by loss of habitat due to conversion to agriculture and human settlement, accidental death, alienation and habitat fragmentation as a result of roads (Peek et al. 2003).

Hunting of grizzly bear is presently regulated in B.C. through a limited entry hunt In the management units that are deemed able to support hunting, there is generally a spring and fall grizzly season. In the Omineca Region, this accounts for a potential annual kill of 207 bears (B. C. Government 2002).

The conversion of natural habitat to agricultural lands and human settlement does not seem to be a limiting factor to the grizzly, however, the intolerance of humans conducting activities in these areas definitely has an impact on grizzly populations (Peek et al. 2003).

Resource extraction, especially forestry has had a wide range of impacts on grizzly populations throughout the interior of B.C. The restriction of natural fires and the reduction in controlled burning has eliminated the natural succession of large areas of potential berry crops and brush cover used by bears for foraging. Current reforestation techniques also tend to reduce berry crops and vegetation by converting cleared land to young forests (with very little understory) very quickly. Also, brush species are considered a hindrance to successful reforestation and are generally reduced through the use of herbicide treatments or other vegetation control measures (Gyug 2002).

Roads and access to remote areas is also a side effect of forestry and mining. The threats caused by roads include, direct mortality through collisions and hunting, displacement due to increased human activity, increased human/bear conflicts, and fragmentation of habitat (McLellan and Shackleton 1988).

Habitat Requirements

Elevation and Forest Stands

General

The seasonal availability and distribution of food dictate bear movements (Pearson 1975). In British Columbia, grizzly bears are found at elevations that range from sea level to >2500m and correspondingly cover a very wide range of forest stand types. One of the key reasons for forest stand selection is the availability of food, however, cover, and security are also important functions of their habitat (Zager and Jonkel 1983, Gyug 2002). The degree of adequate cover depends on the level of access allowed to humans (Jonkel and Demarchi 1984). Greater disturbance levels, or a flat terrain may dictate the need for a higher degree of cover in order for individual bears to exploit the area for food or other uses.

Omineca Region

In the Omineca region, Ciarniello and Paczkowski (2001) described grizzly habitat requirements according to three seasons:

- Spring (late April to June): this period begins with den emergence and includes habitation of the widest elevation range of all seasons. The mean elevation is 1374 m with a range from 877 m to 1,782 m

- Summer (July to August): the mean summer elevation was 1,453 m with a smaller overall range of 1,104 to 1,453 m. This period includes the mating season for grizzly and generally corresponds to the snow free period of higher elevations within the Omineca region.
- Fall (September to October or den-up) – during fall the mean elevation reported was 1,493 m with a range of 1,149 m to 1,772 m. Bears are making final preparations for the winter denning period and are moving towards the upper elevations to find or dig den sites by late October or mid-November.

The use of Alpine habitat far surpassed the use of other forest stand types, with 73% of bears being located in this type. The next most commonly used stand age was old, which would correspond to ESSF within the range of elevations noted in the previous section (Ciarniello and Paczkowski, 2001).

Based on radio telemetry data, the mountain bears in the Parsnip study were highly selective towards ESSFwk2, and its use was significantly greater than its availability (Ciarniello et al. 2002).

Little information is available with regards to stand use by gender or age. Mowat et al. (2002) noted that the use of salmon (*Ocorhynchus* spp.) streams by grizzly bears seemed to preclude their use by black bears.

<u>Denning sites</u>

General

Den sites may be a limiting factor affecting grizzly bear survival in some areas (Jonkel 1987). Depending on latitude and general habitat location (coastal, interior plateau, interior mountain), grizzly bears tend to select from a wide range of suitable den sites. The denning period tends to be slightly longer with increasing latitude, but hibernation usually occurs from November to March or April. Both male and female bears den, although first and second year cubs usually den with their mother (Gyug 2002).

Mature males and females without attendant young tend to leave their dens earlier than do females with yearlings or 2 year olds. Females with new cubs are the last to leave (Banci 1991).

Den sites are often located at high elevations on steep, northerly facing slopes (Bunnell and McCann 1993). The soils in the vicinity of the den sites need to be dry, stable and readily diggable. Also, there should be a vegetated cover, which will act to stabilize the 'roof' area of the den when it is under heavy snow loads (Vroom et al. 1977). Other potential den sites include the boles or caverns under large cedar trees, rock or natural caves, and occasionally underneath large coarse woody debris.

While bears rarely use the same den more than once, they do tend to exhibit fidelity to the same site.

Omineca

Dens were found mostly on North, Northeast and East facing aspects at high elevations in the subalpine and alpine regions of the Omineca. One of the main differences found between mountain and plateau bears is the significant selection for non-classified age (alpine) habitats by mountain bears, and selection for mature and old age classes by plateau bears.

Comparison of Bear Habitat Studies

Because of the large variation in grizzly bear habitat requirements with regions, the comparison of previous studies focused on work carried out in the Prince George District (Table 6).

Selected Habitat Parameters

It is not easy to identify specific habitat parameters that will allow one to predict bear distribution across the landscape. This is because grizzly bears are flexible in habitats they use (Waller and Mace 1997), and they can travel through a diversity of habitats while seeking food. Landscapes with a diversity of stand age classes and structure, and proper cross-altitudinal habitat mosaics, provide bears with adequate food and environmental conditions throughout the seasons (Peek et al. 1987, Ciarniello and Paczkowski 2001). Habitats with abundant food are good bear habitats, as long as animals can forage without being disturbed. In the light of these facts, parameters listed in Table 7 can be used to identify optimal grizzly bear habitats (Fig. 5 and 6). Unfortunately, less valuable landscape segments and stands may still be used by bears for reasons other than habitat quality, e.g., bears have been displaced by humans.

Table 6. Characteristics of grizzly bear habitats in previous studies.

Habitat Characteristics	**Studies/reviews**						
	Ciarniello and Paczkowski 2001	**Ciarniello et al. 2002**	**Proulx and Vergara 2001**	**Banci 1991**	**Vroom et al. 1977 & Bunnell and McCann 1993**	**Pearson 1975 & Servheen 1981**	**Zager and Jonkel 1983 & McLellan and Hovey 2001a**
Biogeoclimatic unit	SBS-ESSF-AT in spring; Upper SBS-ESSF in summer and fall.			Altitudinal vegetation belts from river bottom to alpine			
Cover type	Most cover types; irregular use of pine-dominated stands depending on berry crops.	Alpine & late seral coniferous SBS and ESSF		Early to climax vegetation			
Successional type	1-3 for foraging and denning in alpine; 4-7 for security and foraging in older stands; 7 is particularly important for plateau bears, and for mountain bears, after alpine areas.						
Canopy closure	30-85% :cambium feeding sites 0-90%: bedding sites, berry feeding, and anting sites. 0-75%: carcass sites. 0-85%: grazing.		≥ 30% in forests; 10-30% in early- and mid-seral stages; 0% in openings.				
Basal area			≥ 26 m^2/ha in trees with > 27 cm dbh; 11-18 m^2/ha in trees with > 27 cm dbh in light canopy.				
Dbh			> 27 cm in late seral forests				

Table 6, cont'd

Habitat Characteristics	Studies/reviews						
	Ciarniello and Paczkowski 2001	**Ciarniello et al. 2002**	**Proulx and Vergara 2001**	**Banci 1991**	**Vroom et al. 1977 & Bunnell and McCann 1993**	**Pearson 1975 & Servheen 1981**	**Zager and Jonkel 1983 & McLellan and Hovey 2001a**
Site type							
Understory			≥ 20% cover when determined in winter; ≥ 34% cover in summer; ≥ 15,000 stems (0.6-2.5 m high)/ha				
Coarse woody debris			≥ 28 cm	Impacts of road development: dissection of habitats and home ranges, direct mortalities from roadkills and legal and illegal harvests, displacement of bears away from roads, habitat loss.			
Snags			> 18 snags/ha. Some snags > 50 cm for denning				
Impact of disturbance							
Contiguity							It is necessary to maintain corridors of habitat between major protected areas that are also good habitat themselves. Corridors must be wide enough for male grizzly bears to live in with little risk of being killed.

Table 6, cont'd

Habitat Characteristics	Studies/reviews						
	Ciarniello and Paczkowski 2001	**Ciarniello et al. 2002**	**Proulx and Vergara 2001**	**Banci 1991**	**Vroom et al. 1977 & Bunnell and McCann 1993**	**Pearson 1975 & Servheen 1981**	**Zager and Jonkel 1983 & McLellan and Hovey 2001a**
Elevations	877-1782 m in spring; 1104-1453 m in summer; 1149-1772 m in fall.	Mountain bears: mid to high elevations corresponding to slide alder and avalanche chutes. Plateau bears: low elevations.					
Slopes							
Special features				River floodplains, benches and avalanche chutes are important in spring.			
dens	N, NE, and E facing aspects in subalpine and alpine regions for mountain bears. Mature and old age classes for plateau bears. Denning under stumps/roots for roof stabilization.				High elevations on steep, northerly facing slopes. Soils dry, stable, and readily diggable, with vegetated cover to stabilize the roof area.	Located at high elevations in remote areas with slopes > 30°, soils that are deep, and aspects where snow accumulates.	

Table 7. Series of parameters that may be used to develop grizzly bear distribution predictive maps.

Parameter	***Habitat requirement***	***Justification***	***References***
		Landscape Level	
Contiguous landscape segment	≥ 100 km^2 areas consisting of ≥ 500-m-wide contiguous/connected landscape segments.	A 100 km^2 area corresponds to the minimum home range size for most bear populations inhabiting central B.C..	Mowat et al. (2002) Ciarniello et al. (2002)
Biogeoclimatic zones included in the landscape segment	AT, ESSFp, ESSF, SBS, ICH	Seasonal habitat needs. Almost all Biogeoclimatic zones in the province are suitable for some part of grizzly habitat. However, in the Omineca studies, the AT, ESSFp, ESSFwk2 were selected for by mountain bears, while the SBSwk1 was selected for by Plateau bears (significantly more than their availability would suggest).	Meidinger and Pojar (1991) Ciarniello and Paczkowski (2001) Gyug 2002 Ciarniello et al. (2002)
Cover types	Non-forested sites in the alpine. Coniferous sites in upland forests. Openings with well developed vegetation (brush and berries). Riparian areas, avalanche chutes.	Non-forested sites in the alpine are used for summer grazing and winter denning. Coniferous sites in upland forests are used for early spring and summer foraging, bedding, and security. Mostly Bl, Sx or Bl (Sx). Openings with well-developed vegetation are used for foraging. Foraging – these disturbed areas tend to maintain an early seral stage for prolonged period and therefore provide healthy, young vegetation almost in perpetuity. As well, the riparian areas provide temperature relief and cover.	Banci (1991) Ciarniello et al. (2002) Ciarniello and Paczkowski (2001) Gyug (2002) Peek et al. (2003)
Cover type (% of landscape segment)	Non-forested portion (60-75% of landscape segment – see Fig.5). Proportion of Biogeoclimatic zones in non-forested (meadows, krummholz areas, etc.) habitats: Alpine = 15.0 to 50.0 % ESSF = 50% SBS = 50 % Forested portion (25-40% of landscape segment – see Fig.5).	The non-forested portion provides winter denning, summer forage and late fall forage. The large proportion of non-forested area is based on telemetry studies indicating that bears favored these sites. The forested portion provides mountain bears with spring forage and some summer berry supplies; it provides plateau bears with thermal security and escape cover. Although bears prefer openings and avalanche chutes, adjacent forests provide bed sites and escape cover . .	Waller and Mace (1997) Ramcharita (2000) Ciarniello et al. (2002) Ciamiello and Paczkowski, (2001) Most western Canadian and U.S. studies

Snow	Large accumulations required during the denning period.	Snow depth required for denning. .	Pearson (1975) Servheen (1981)
Roads	0.6km/km^2	Roads are currently responsible for habitat loss, fragmentation, and increased mortality due to higher amount of human/bear interactions. Reducing active roads to below this level should take these pressures off of grizzly populations.	McLellan and Shackleton 1988
Elevations	750 to 2500 m	These elevations correspond with the complete range of radio-collared bears in the Parsnip study area. In the Omineca region this range coincides with most suitable forage habitat for both mountain and plateau bears.	Ciarniello 2002
Hillshade & Aspects	Hillshade: S, SE and SW aspects Denning: N, NE and E	Increased productivity for vegetation, so increased use as forage areas. These aspects are associated with greater snow accumulations	Vroom et al. (1977) Bunnell and McCann (1993) Ciarniello and Paczkowski (2002)
		Stand Level	
Structural stages	Mountain bears: Classes1-3 for foraging and denning; classes 6-7 for security and foraging Plateau bears: Classes 1-3 for foraging; classes 4-7 for security; and classes 6-7 for denning and foraging.	Mountain bears select for alpine areas more than any other habitat. However they still use adjacent cover during some seasons. The plateau bears select for young (0-45yrs) and cut blocks with regeneration. However, they also use forest cover for denning, thermal security, and escape cover. Stages 6-7 provide bears with large CWD where they can find food (e.g., grubs).	Ciarniello and Paczkowski, 2001. Ciarniello et al. 2002 Gyug 2002
Age class	Classes 1-2 for food and denning (mountain bears) Classes 5-9 for thermal security, escape cover and foraging Class 9 for foraging (open forests), thermal protection, escape cover and denning (plateau bears).	Bears use a mosaic of habitats of various age and structure.	Jonkel (1987) Banci (1991)
Tree dbh	≥ 27 cm in late seral stages	Although bears spend relatively less time in forested sites, they seasonally seek late seral stages.	Proulx and Vergara (2001)

			Gyug (2002)
Canopy closure	0% in openings ≥10 % in forests	Bears will use all forest types for security and foraging.	Proulx and Vergara (2001) Gyug (2002)
Basal area	≥ 11-18 m^2/ha in mature trees in young forests ≥ 20 m^2/ha in late seral stages	A ≈11m^2/a basal area provides moose with sufficient cover when they are feeding in cut blocks; it also provides bears with hiding cover. A ≥ 20 m^2/ha basal area is typical of late seral stands where plateau bears may find denning sites.	Peek (1997) Proulx and Vergara (2001) Gyug (2002)
CWD	Presence of large CWD of decay class 1 and 2	Feed for grubs. Recent management strategies suggest the retention of 50% of the largest CWD of decay class 1 and 2	Gyug (2002)
Rock outcrops	-	Although rock outcrops have been used opportunistically for den sites, there is no trend towards a selection for this parameter.	Ciarniello and Paczkowski 2001
Snags	> 19 snags (> 20 cm dbh)/ha	Required for CWD recruitment.	Proulx (2001). Gyug (2002)
Understory	Class 2 – herb layer Class 3a – low shrub layer Class 3b – high shrub layer	Very important source of early forage during vegetation emergence. Found in avalanche chutes, meadows. Very high use especially if vaccinium species are present. Very high use especially if vaccinium species are present along with alder (*Alnus* spp.) , skunk cabbage (*Lysichiton americanum*) and other riparian vegetation (sedges, grasses, etc.) Note: Ciarniello et al (2002) found greenness be the most important parameter selected for by mountain bears.	Ciarniello et al. (2002) Gyug (2002)
Food supplies	Roots, corms, herbs, berries, vegetation, salmon (if available), marmots and ground squirrels, neonatal ungulates, carrion.	Since grizzly are basically omnivores with a very large portion of their diet composed of vegetation, they are able to thrive on a wide variety of food types.	All grizzly habitat studies

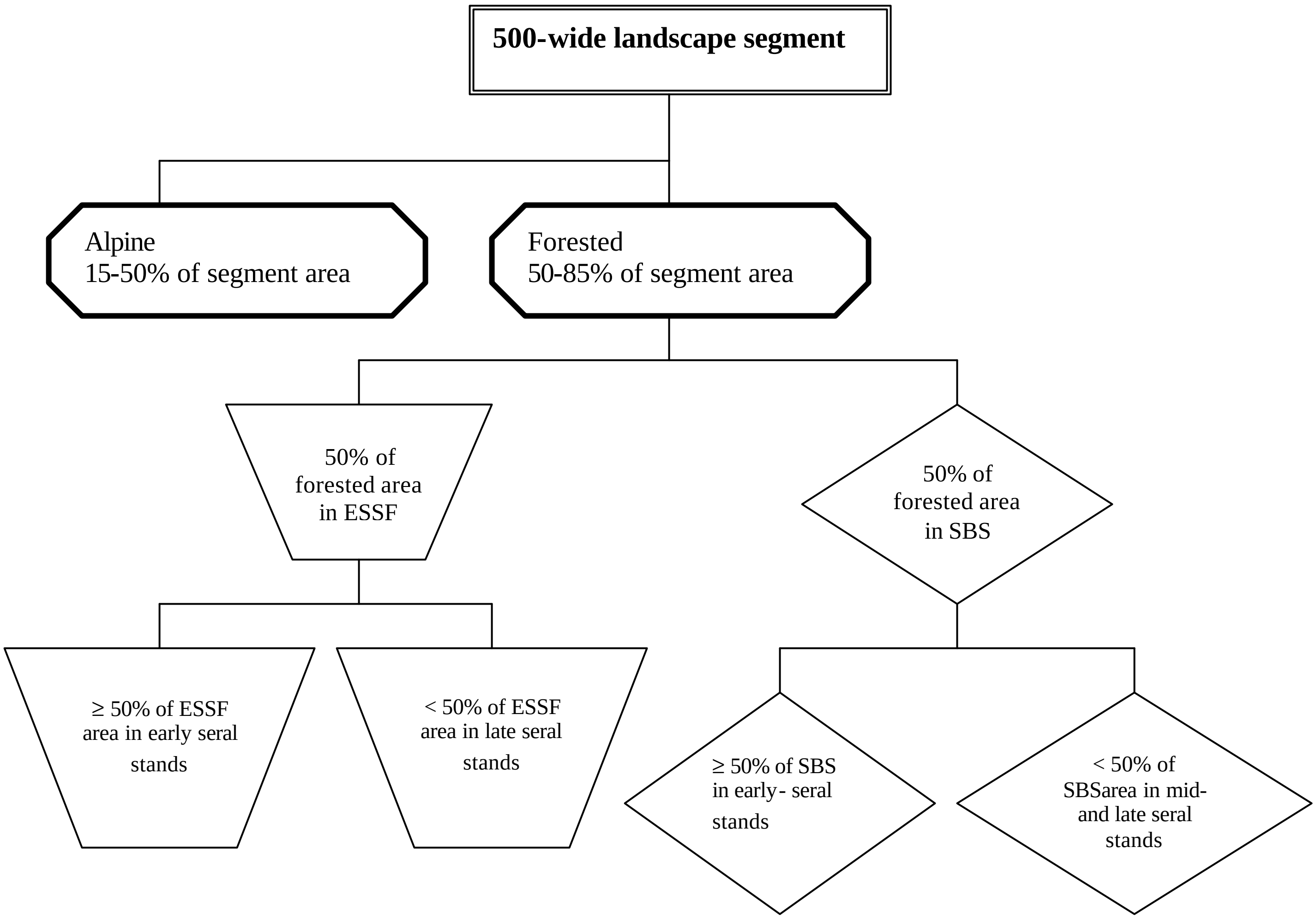

Figure 5. Creation of a grizzly bear landscape segment.

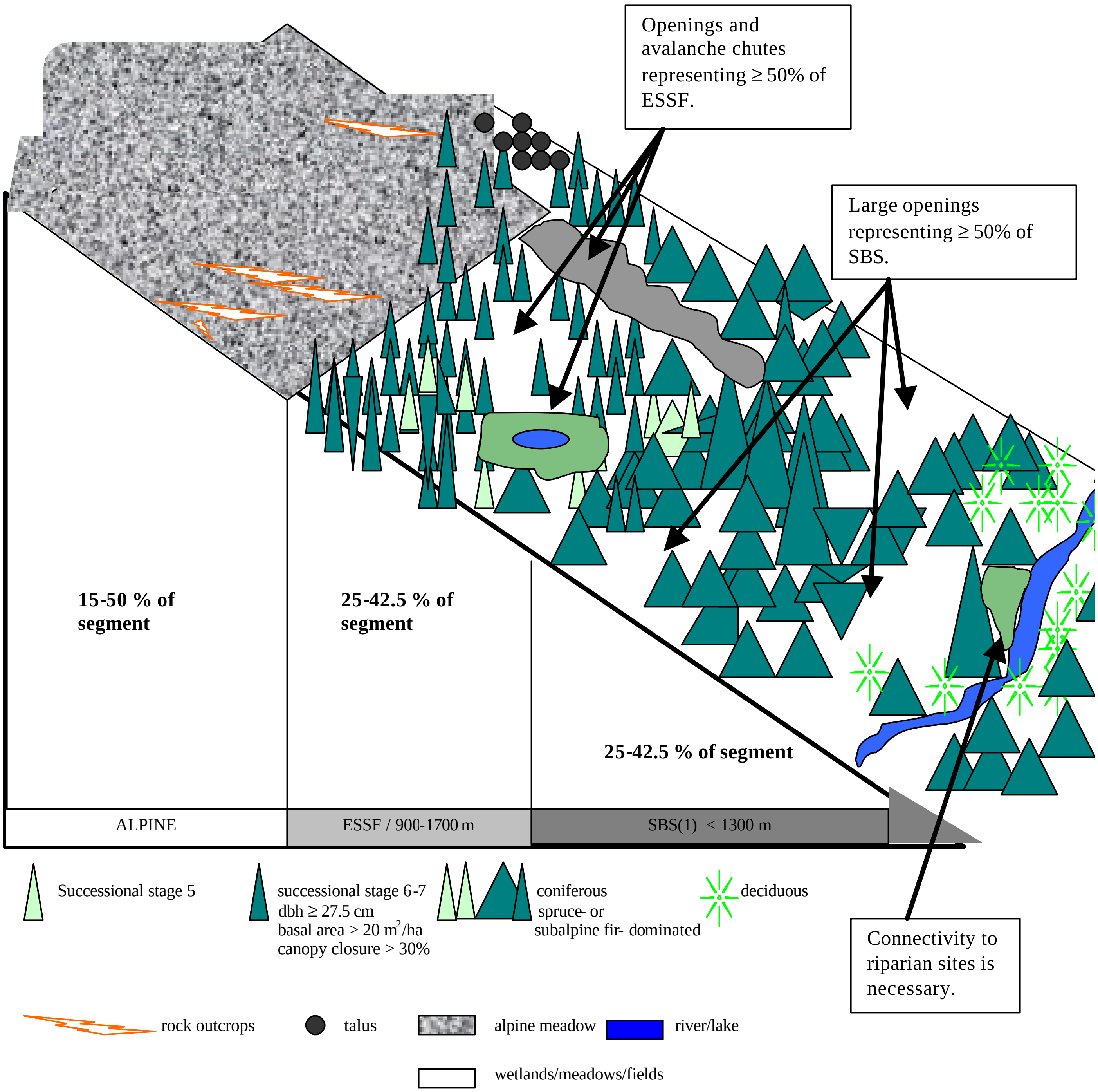

Figure 6. Example of an optimal landscape segment (³ 100 km^2) for grizzly bear (£ 0.6 km/km^2 of active roads).

MOUNTAIN CARIBOU

Species Account

Description

Mountain caribou are a group or ecotype of woodland caribou that inhabit the deep snowpack ecosystems of British Columbia (Terry et al. 2000). Mountain caribou are large ungulates that weigh between 90-275 kg and cannot be distinguished visually from the boreal or northern caribou ecotypes, but are differentiated from them by food type and habitat location. Both sexes have antlers and large crescent shaped hooves, which allow the animals to move through deep snow and bogs (Cichowski 2003).

Status

The mountain caribou is presently a blue listed species in British Columbia and is considered a species of 'special concern' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). There are approximately 1900 of these caribou in B.C., which inhabit the southeastern and central eastern mountain ranges, with a small population existing in Idaho. Since 1997 population numbers have been declining.

Distribution

The range of mountain caribou in B.C. extends from the Hart Ranges in the north through the interior wet belt (ICH) and down to the U.S./Canada border (Schmidt, McNay, 2002). There are only a couple isolated herds in the southern half of the province (listed as 'threatened' by COSEWIC), with the largest herds being found north of Kamloops. These more northerly herds account for approximately 90% of the mountain caribou population. The Yellowhead herd in the Prince George area encompasses approximately 40% of the BC mountain caribou population.

Population Dynamics

Caribou breed during a brief period in late September to October, and calves are usually born about 230 days later in May and June. Each cow gives birth to only one calf per year. Calf mortality is quite high during the first two or three months and often approaches 50%. Causes of mortality may include poor weather, predation, abandonment and accidents. Females reach sexual maturity by 1.5 years with mean pregnancy rates ranging from 82 to 85% for herds with healthy cow numbers. While mountain caribou are considered gregarious, they rarely form large groups like other caribou ecotypes, and are generally found in groups of less than 25 animals (MCTAC 2002, Cichowski 2003).

Home Ranges/Habitat

Caribou require large tracts of undisturbed landscape, which incorporates old growth conifer forests and access to alpine parkland areas. Minimum home ranges of 150-600 km^2 are typical but can vary from <100 to > 800 km^2. Habitats within the home range vary by season and are driven by nutritional requirements and prey avoidance (Cichowski 2002).

Omineca Seasonal Habitats

Early Winter (Late October – mid-January)

From October to mid January, mountain caribou inhabit low to mid-elevations (1525 to 1677 m) associated with ESSF, and sometimes range down into the ICH biogeoclimatic subzones where suitable shrubs and herbs are available (Terry et al. 2000). Johnson (2002) found that the Yellowhead herd was highly selecting for elevations between 1601-1900 m during this same season. These differences may be a result of seasonal and yearly climatic changes or individual landscape location. As snow depths start to reach 50 cm, terrestrial food sources become too difficult to obtain, and movement to upper elevations begins (Cichowski 2003).

Late Winter (mid January – April)

Starting in late January, snow depths accumulate and settle in the upper ESSF elevations (>1677m) providing a 'lift' for caribou, which allows them to reach arboreal lichens in the canopy. This area consists mostly of subapline parkland with low volume Bl (Se) stands (Terry et al. 2000). Mountain caribou will stay at these high elevations until mid-April or May when snow conditions again force them down into the lower ESSF and ICH areas.

Spring (mid April – late May)

As the lower elevations become snow free, caribou move down to take advantage of evergreen shrubs and herbs found in the lower ESSF and ICH areas. They are quite often found to forage in relatively open sites during this time of the year (Cichowski 2003).

When calving season approaches, the pregnant females will often move back up into the higher elevations, and separate themselves from other caribou. This behavior would allow caribou to avoid predators (Poole et al. 2000, Wood 1994).

Summer (June – late October)

As the upper elevations become snow free, caribou again move up into the high elevation ESSF, ESSF parkland and further into alpine meadows. The majority of the summer months and early fall is spent in these areas.

<u>Food Habits</u>

Mountain caribou survive almost exclusively on arboreal lichens during the late winter and early spring seasons, specifically the beard lichens, *Alectoria sarmentosa* and *Bryoria* spp. These lichens are generally found throughout the canopy of older Bl(Sx) forests that exhibit multi-storied stand structure. If accessible, these lichens are used for foraging in all seasons.

During the late spring and summer months, caribou graze on a wide variety of forbs, graminoids, lichens, fungi and the leaves of some low shrubs such as vaccinium (*Vaccinium* spp.), and falsebox (*Pachistima myrisinites*) (Cichowski 2003).

Threats

The main threat to mountain caribou is the loss of large expanses of undisturbed habitat. Results of habitat fragmentation include: increased predation (natural predators and humans), loss of food source (and increased effort in attaining food), and population isolation (Terry et al. 2000, Stevenson et al. 2001, MCTAC 2003).

Predation

The key predators for mountain caribou include wolf (*Canis lupus*), grizzly bear, cougar (*Felis concolor*), and wolverine.

While winter losses due to predation have historically been quite low, the increased interaction with other species such as moose and deer (Odocoileaus spp.) due to changing forest cover types as a result of forest management and timber harvesting, has resulted in increased predation by wolves and cougars (MCTAC 2002, Seip 2002, Terry et al. 1994, Stevenson et al. 2001). In the TFL #30, however, because the road network within the ESSF biogeoclimatic unit is not extensive, it is unlikely that wolf impacts significantly on caribou populations at high elevations (C. Johnson, 2003, pers. commun.).

As well as natural predators, caribou numbers are impacted by hunting and human interactions. As roads and resource development move further into undisturbed areas, the threat of negative interactions with humans also increases (Cichowski 2003).

Food Source

The arboreal lichens which caribou feed on during the winter months are generally slow growing and found in low densities (as compared to other vegetation types). As a result, caribou must have large areas where they can obtain this food source if it is to remain viable over years of use. Old growth forests are generally required because of long rotation periods (>150 years) required to re-establish sufficient arboreal lichen biomass (Armleder and Stevenson 1996).

Habitat Fragmentation

As habitats become fragmented, the ability of mountain caribou to maintain a thrifty gene pool becomes more limited. The isolation of small herds can be seen on distribution maps of the species in B.C. While the affects of this type of threat may take the longest to materialize, they may have the biggest impact on the long term viability of mountain caribou populations (Stevenson et al. 2001, Cichowski 2003). Connectivity across the landscape is an important factor in the development of a mountain caribou management program.

Habitat Requirements

Because of the peculiarities of the mountain caribou populations inhabiting the Prince George District, a comparison of various habitats of *Rangifer tarandus* described in the scientific literature was not judged necessary. The following focuses on the Mountain Caribou habitats encountered in TFL # 30 and surrounding landscapes.

Elevations and Forest Stands – Omineca Region

Elevations

Mountain caribou in the Omineca area generally inhabit elevations between 750m and 2100 m, with the majority of their time being spent above 1200m (Terry et al. 2000, Cichowski 2003).

Forest Stands

Unlike the mountain caribou of southeastern B.C., the herds in the Omineca region still have quite large numbers and fairly easy access to large expanses of undisturbed old growth. While there is some ICH north of McBride, the shrub species differ enough that use of the ICH is much more limited in the Omineca region than it is in areas south of McBride. This means that caribou in the Omineca tend to remain within the ESSF and AT areas more so than the southern caribou.

In the Omineca, mountain caribou use SBS and ICH stands at low elevations (650 and 1220 m, respectively). These stands are used minimally by mountain caribou except for being suitable for connectivity between preferred high-levation landscapes.

Englemann spruce and Subalpine fir (ESSF) dominate forest stands between 1220 m and 1677 m, while at higher elevations subalpine fir becomes the main timber species. Above 1677 m the subalpine fir begins to grow in clumps and is quite stunted in height, this is commonly referred to as the ESSF parkland zone. The Alpine Tundra exists above 1800 m where lush open meadows provide forage for both caribou and grizzly bear during summer months.

The high-elevation AT and ESSF parkland are the most removed from potential conflicts with timber extraction and forestry, so much of the late winter and summer mountain caribou habitat will be protected by default. However, at lower elevations the ESSF and upper SBS become much more productive timber sites (volumes of $200m^3$/ha and greater), and disturbance due to timber harvesting and road building/use can result in habitat fragmentation (Simpson et al. 1994). Since these habitats are critical during the spring season, most management considerations and caribou recovery strategies focus their attention in this area (MCTAC 2002).

Selected Habitat Parameters

Parameters listed in Table 8 can be used to develop optimal landscape segments for mountain caribou (Fig. 7 and 8).

Table 8. Series of parameters that may be used to develop caribou distribution predictive maps.

Parameter	***Habitat requirement***	***Justification***	***References***
Landscape Level			
Contiguous landscape segment	≥ 100 km^2 areas consisting of ≥ 500-m-wide contiguous/connected landscape segments.	≥ 100 km^2 areas correspond to minimum home range areas. Large tracts of continuous old forest with specific habitat criteria are required by mountain caribou to support their grazing on arboreal lichens during the winter months. This minimum width is required to provide caribou with enough cover and foster movements from one habitat to another.	Harrison & Surgenor (1994) Rae-Chute (1999) Stevenson et al. 2001 Cichowski (2003)
Biogeoclimatic zones included in the landscape segment	Alpine, ESSFp, ESSF, ICH (in more southerly regions of BC).	Seasonal habitat needs driven by predator evasion and foraging.	Seip (2002) Simpson et al. (1994) Terry et al. (2000)
Cover types	Old or mature coniferous forests representing relatively high elevations. Shrubby alpine	Mountain caribou spend most of the late winter and early spring seasons foraging on arboreal lichens in these stands. Shrubby alpine is used during late spring for calving, and throughout the summer for grazing on herbaceous cover.	Stevenson et al. (2001) Cichowski (2003)
Cover composition (% of landscape segment)	<u>Contiguous forest cover</u> (>70% of landscape) consisting of old coniferous stands (high elevation) <u>Shrubby alpine</u> Dominated by open meadows and krummholz stands. Without contiguous cover (< 40% of landscape): snow, rock, alpine tundra, or second growth forest.	Late Winter range requirements: ≥ 80% Bl in low volume stands <100m^3/ha Early Winter range requirements: ≥ 80% Bl in slightly higher volume stands ranging from 201 to 300 m3/ha. Also < 20% Se or Sx, with basal areas <27m^2 . Subalpine fir and Spruce stands provide wildlife with complex horizontal and vertical structures, therefore with security cover and food supplies. These forests are used by wolverine (an important predator). In order to meet caribou 's needs, openings in ESSF must be kept small. The total area without cover in the forested portion of the landscape segment amounts to < 30%. This is largely based on marten ecology.	Simpson et al. (1994) Terry et al. (2000) Proulx (2001) Stevenson et al. (2001) MTCAC (2002)

Stand Level			
Structural stages	Stage 2 - alpine shrubland Stages 6 and 7 in forested habitats for foraging and security. Stages 5-7 for traveling.	The diversity of structural stages meets the seasonal needs of the species.	McLellan and Shackleton (1988)
Tree dbh	> 20 cm, but preferably ≥ 27.5 cm.	Trees of this size are usually associated with mature forests with structural complexity. Caribou do not select trees with a minimum dbh for foraging on arboreal lichens. However, older forests, and therefore larger trees, encompass stands that are rich in such lichens (S. Stevenson, 2003, pers, commun.).	Terry et al. (2000) Proulx and Kariz (2001a, 2002).
Canopy closure	< 10% in alpine; ≥ 30 % in forests	Closed forest canopy accommodates late-seral species such as marten and caribou. During deep snow periods, moose also seeks such forests, but generally at lower elevations.	Proulx and Joyal (2001) Proulx (2001) Stevenson et al. (2001)
Basal area	0 in non-forested sites < 27 m^2/ha in mature trees in contiguous undisturbed forested areas ≈20m^2/ha after stands have been logged with a non-clearcut harvest system.	Alpine tundra sites are void of trees, therefore a basal area of '0' is applied. <20 m^2 basal area in mature trees, allows for an open habitat with good visibility and also maintains proper conditions for lichen growth. Conservative management measures aim for a basal area of 20 m^2 /ha in mature trees after selective harvest.	Terry et al. (2000) Stevenson et al. (2001)
CWD	N/A	Too much can hinder travel, but no quantitative values available.	Stevenson et al. (2001)
Snags	> 19 snags (> 20 cm dbh) /ha or 25-35% of the canopy in old stands	Snags support up to 35% of the lichen biomass in ESSF stands. This can be an important source of food when branches fall. Presence of snags is related to late-seral stages, greater structural complexity, and generally greater biodiversity.	Terry et al (2000)
Understory	Low shrubs only.	To maintain good visibility and predator evasion, caribou prefer low amounts of understory that are both easy to see through and move through. Also, low evergreen shrubs provide forage. In ESSF stands, caribou prefer those stands with minimum rhododendron (*Rhododendron* spp.) false azalea (*Menziesia ferruginea*) and alder.	Stevenson et al (2001)

Snow & Temperatures	>1 m of snow in late winter	Snow depth required to provide 'lift' to reach canopy lichens	Cichowski (2003)
Food supplies	Winter - Arboreal lichen Summer - Low shrubs and plants	Winter forage is monophagous and comprised of *Alectoria sarmentosa* and *Bryoria* spp (beard lichens). Falsebox, Bunchberry (*Cornus canadensis*), Five-leaved bramble (*Rubus pedatus*(), *Vaccinium* spp., willows (*Salix* spp.), grasses, sedges (*Carex* spp), horsetail (*Equisetum* spp.), flowering plants and the leaves of numerous low shrubs.	MCTAC (2002) Previous studies.
Calving	Alpine and subalpine habitats	While most caribou are still foraging at lower elevations, the females about to calve separate themselves from the rest of the group and search out secluded sites in the alpine and subalpine. This form of habitat segregation is believed to be a predator evasion technique.	Wood (1994)
Site productivity	Low	A function of many ESSF stands rather than a parameter caribou are selecting for.	Stevenson et al. (1994:5)
Slope and Terrain	16-30% slopes on rounded mountains with gentle sub-alpine bowls.	While caribou seems to select for this range of slopes, it might be due to the fact that adequate forest stands are found on these grounds in this landscape (D. Seip, 2003, pers. commun.)	Seip (2002) Terry et al. (1994)

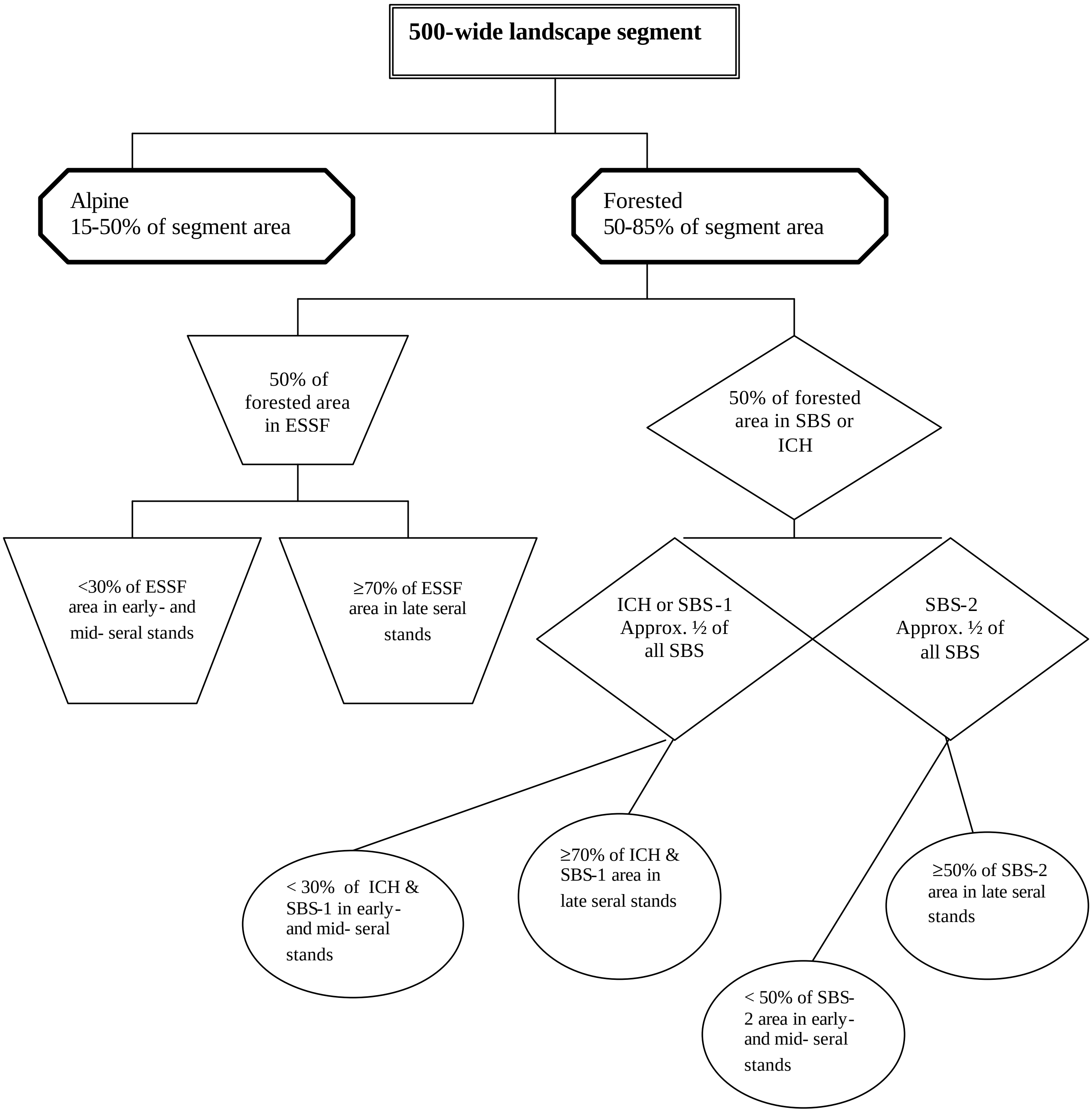

Figure 7. Creation of a caribou landscape segment.

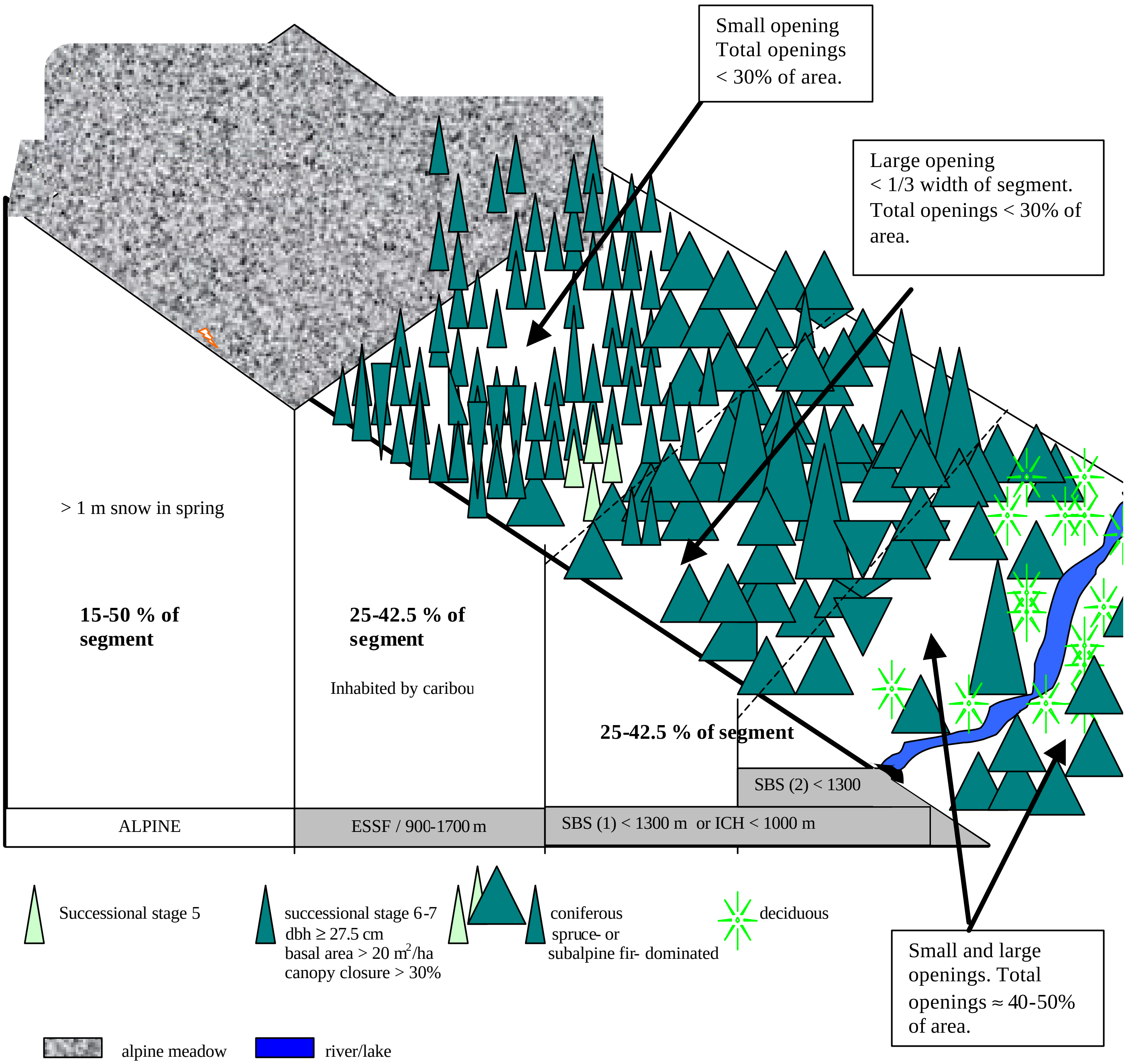

Figure 8. Example of an optimal landscape segment (³ 100 km^2) for mountain caribou (whenever possible, select landscape segments with < 0.6 km/km^2 of active roads in ESSF and SBS [2]). Where ICH is present, keep non-forested sites to < 30% of the landscape portion. Openings of 40-50% apply to SBS (2) only.

DISCUSSION & RECOMMENDATIONS

Wolverine and mountain caribou have seasonal requirements that involve altitudinal movements ESSF and AT. Both species require escape cover, food that is associated with late seral stages, and alpine and subalpine grounds for denning/calving. Furthermore, wolverine preys on caribou. Predictive distribution maps will likely stress the similarities that exist between these species' habitat requirements. However, because wolverine extends its activities in the SBS biogeoclimatic unit, which is relatively rich in moose, the wolverine distribution range will certainly encompass larger areas.

Because fisher movements are impeded by snow depth, and the species depends greatly on the presence of large denning trees (particularly declining cottonwoods), it is likely that predictive distribution maps will include mainly SBS riparian forested areas.

Of all the species reviewed in this project, the grizzly bear is certainly the least predictable species due to its great flexibility in habitat selection. Bears can inhabit all the landscape under study, and its distribution range will certainly overlap with those of other species. On the other hand, by focusing on openings such as meadows, avalanche chutes (which are likely scarce in TFL # 30), mid- and high-elevation wetlands, and potential denning areas, it may be possible to better define optimal sites for this species. In the case of wolverine and grizzly bear, the impact of roads on their distribution within the study area may not be easily predictable. Animals react differently to roads depending on their use by humans, remoteness, right-of-ways characteristics, etc. In remote areas, both species may use habitats that may be avoided in other regions of the landscape because of human disturbance. For example, McLellan and Hovey (2001b) found that the bear population of the Flathead River drainage in southeastern British Columbia, which is not restricted to mountainous terrain by severe habitat alteration and excessive mortality at lower elevations, selected habitats differently from other bear populations, and showed strong selection for some low elevation habitats. It will therefore be important to refine habitat queries in the light of field observations.

Field validation will therefore be required to assess the suitability of the proposed parameter series, and the accuracy of the predictive maps. Because species habitat requirements vary on a seasonal basis, and sometimes among years, it is recommended that validation of predictive maps involves more than one year of field observations, and be carried out over many months each year in order to detect seasonal changes in habitat utilization.

LITERATURE CITED

Allen, A. W. 1983. Habitat suitability index models: fisher. U.S. Fish Wildlife Service, FWS/OBS-82/10.45.

Armleder, H. M., and S.K. Stevenson. 1996. Using alternative silviculture systems to integrate mountain caribou and timber management in British Columbia. 6th North American Caribou Workshop, Prince George BC, Pp. 141-148.

Aubry, K. B., and D. B. Houston. 1992. Distribution and status of the fisher in Washington. Northwest Naturalist 73: 69-79.

Aubry, K. B., D. B. Houston, C. M. Raley, T. J. Catton, and G. W. Tomb. 2001. Ecological characteristics of fishers in southwestern Oregon: Annual report. USDA Forest Service, Pacific Norwest Research Station, Olympia, Washington.

Badry, M. J. 2003. Fisher. IWMS species account, B.C. Ministry of Water, Land and Air Protection, Victoria.

Badry, M. J., G. Proulx, and P. M. Woodard. 1997. Home range and habitat use by fishers translocated to the aspen parkland of Alberta. Pages 233-251 *in* G. Proulx, H. N. Bryant, and P. M. Woodard, editors, *Martes*: taxonomy, ecology, techniques, and management. Proceedings 2nd *Martes* Symposium, Provincial Museum of Alberta, Edmonton.

Bailey, T. N. 1981. Factors influencing furbearer populations and harvest on the Kenai National Moose Range, Alaska. Pages 249-272 in J. A. Chapman and D. Pursley, editors, Worldwide Furbearer Conference Proceedings, Frostburg, Maryland.

Banci, V. 1987. Ecology and behavior of wolverines in Yukon. M.Sc. Thesis, Simon Fraser University, Burnaby.

Banci, V. 1991. The Status of the grizzly bear in Canada in 1990. COSEWIC Status Report, Ottawa.

Banci, V. 1994. Wolverine. Pages 99-127 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. Zielinski, editors, The scientific basis for conserving forest carnivores. American marten, fisher, lynx, and wolverine in the Western United States. USDA, Forest Service, General Technical Report RM-254, Fort Collins, Colorado.

Banci, V., and A. S. Harestad. 1988. Reproduction and natality of wolverine (*gulo gulo*) in Yukon. Ann. Zool. Fenn. 25: 265-270.

Banci, V., and G. Proulx. 1999. Resiliency of furbearers to trapping in Canada. Pages 175-204 *in* G. Proulx, editor, Mammal trapping. Alpha Wildlife Research & Management Ltd., Sherwood Park, Alberta.

Bjärvall, A. 1982. A study of the wolverine female during the denning period. Transactions of the International Congress of Game Biologists 14: 315-322.

Bjärvall, A. , R. Franzén, and E. Nilsson. 1978. Järvenenstöring I nor. Forskning och Framsteg 1: 21-28 (In Swedish).

British Columbia Government. 1995. Fisher. Wildlife Habitat Rating for Central Interior. British Columbia Ministries of Sustainable Resource Management and Water, Land and Air Pollution, Victoria.

British Columbia Government. 2002. Hunting and trapping regulations synopsis. B.C. Min. Water, Land and Air Pollution, Victoria.

British Columbia Ministry of Forests and Ministry of Environment, Lands and Parks. 1995a. Biodiversity guidebook.Victoria.

British Columbia Ministry of Forest and Ministry of Environment, Lands and Parks. 1995b. Riparian management area guidebook. Victoria.

Buck, S., C. Mullis, and A. Mossman. 1983. Final report: Corral Bottom-Hayfork Bally fisher study. USDA and Humboldt St. Univ., Arcata.

Bunnell, F. L., and R. K. McCann. 1993. The brown or grizzly bear. *In* Bears: Majestic creatures of the wild. Rodale Press, Emmaus, Pennsylvania.

Campbell, R. W., N. K. Dawe, I. McTaggart Cowan, J. M. Cooper, G. W. Kaiser, and M. C. E. McNall. 1990. The birds of British Columbia. Royal British Columbia Museum and Canadian Wildlife Service, Victoria.

Canadian Forest Products (Canfor). 2002. Sustainable forest management plan. Fort St. James & Prince George Operations, Mimeograph.

Cannings, R. A., R. J. Cannings, and S. G. Cannings. 1987. Birds of the Okanagan Valley, British Columbia. Royal British Columbia Museum, Victoria.

Ciarniello, L. M. Boyce, and H. Beyer. 2002. Grizzly bear habitat selection: along the Parsnip River, British Columbia. University of Alberta report submitted to Prince George Forest Region.

Ciarniello, L. M. and J. Paczkowski. 2001. Parsnip grizzly bear population and habitat project – 2000 Progress Report. Forest Renewal B.C.

Cichowski, D. 2003. Woodland caribou. *Rangifer tarandus caribou*. Draft species account for Identified Wildlife Management Strategy, Victoria.

Conroy, M. J., L. W. Gysel, and G. R. Duddedar. 1979. Habitat components of clear-cut areas for snowshoe hares in Michigan. Journal of Wildlife Management 43: 680-690.

Coulter, M. W. 1966. Ecology and management of fisher in Maine. Ph.D. Thesis, Syracuse Univ., N.Y.

Coupé, R., A. C. Stewart, and B. M. Wikeem. 1991. Engelmann spruce-subalpine fir zone. Pages 223-236 *in* D. Meidinger and J. Pojar, editors, Ecosystems of British Columbia. B.C. Ministry of Forests, Victoria.

Craighead, F. C., Jr., and J. J. Craighead. 1972. Grizzly bear pre-hibernation and denning activities as determined by radiotracking. Wildlife Monograph 32.

deVos, A. 1952. Ecology and management of fisher and marten in Ontario. Ontario Department Lands and Forest Technical Bulletin, Wildlife Series 1.

Dodds, D. G. 1987. Nova Scotia's snowshoe hare. Life history and management. Nova Scotia Department Lands and Forests.

Douglas, C. W., and M. A. Strickland. 1987. Fisher. Pages 511-529 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors, Wild furbearer management and conservation in North America, Ontario Trappers Assoc., North Bay, Ont.

Farhig, L., and J. Paloheimo. 1988. Determinants of local population size in patchy habitats. Theoretical Population Biology 43: 194-213.

Frost, H. C., and W. B. Krohn. 1997. Factors affecting the reproductive success of captive female fishers. Pages 100-109 *in* G. Proulx, H. N. Bryant, and P. M. Woodard, editors, *Martes*: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alta.

Gardner, C. L. 1985. The ecology of wolverines in southcentral Alaska. M.Sc. Thesis, University of Alaska, Fairbanks.

Gilbert, J. H., J. L. Wright, D. J. Lauten, and J. R. Probst. 1997. Den and rest-site characteristics of American marten and fisher in northern Wisconsin. Pages 135-145 *in*

G. Proulx, H. N. Bryant, and P. M. Woodard, editors, *Martes*: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alta.

Gyug, L. W. 2002. Grizzly bear. *Ursus arctos horribilis*. Draft species account for Identified Wildlife Management Strategy, Victoria.

Haglund, B. 1966. Winter habits of the lynx (*Lynx lynx*) and wolverine (*Gulo gulo* L.) as revealed by tracking in the snow. Viltrevy 4:81-309.

Harrison, S., and J. Surgenor. 1994. Issues of caribou management in northeastern British Columbia. . 6th North American Caribou Workshop, Prince George, BC., Pp. 127-130.

Hatler, D. F. 1989. A wolverine management strategy for British Columbia. B.C. Ministry of Environment Wildlife Bulletin No. B-60, Victoria.

Hayes, J. P., and S. P. Cross. 1987. Characteristics of logs used by western red-backed voles, *Clethriionomys californicus*, and deer mice, *Peromyscus maniculatus*. Canadian Field-Naturalist 101: 534-546.

Heinemeyer, K. S. 1993. Temporal dynamics in the movements, habitat use, activity, and spacing or reintroduced fishers in northwestern Montana. M.Sc. Thesis, university of Montana, Missoula.

Hornocker, M. G., and H. S. Hash. 1981. Ecology of the wolverine in northwestern Montana. Canadian Journal of Zoology 59: 1286-1301.

Hummel, M., and S. Pettygrew. 1991. Wild hunters. Predators in peril. Roberts Rinehart Publ., Niwot, Colorado.

Hutto, R. L., and J. S. Young. 1999. Habitat relationships of landbirds in the northern region. USDA Forest Service Gen. Tech. Report RMRS-GTR-32.

Ingram, R. 1973. Wolverine, fisher and marten in central Oregon. Oregon State Game Commissioners, Central Region Administration Report No. 73-2.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resources preference. Ecology 61: 65-71.

Johnson, S. A. 1984. Home range, movements, and habitat use of fishers in Wisconsin. M.Sc. Thesis, Univ. Wisconsin, Stevens Point.

Jones, J. L. 1991. Habitat use of fisher in northcentral Idaho. M.Sc. Thesis, university of Idaho, Moscow.

Jones, J.L., and E. O. Garton. 1994. Selection of successional stages by fishers in northcentral Idaho. Pages 377-387 *in* S. W. Buskirk, A. Harestad, M. Raphael, and R. A. Powell, editors, Martens, sables, and fishers: biology and conservation. Cornell Univ. Press, Ithaca, N.Y.

Jonkel, C. J. 1987. Brown bear. Pages 457-473 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch. Editors, Wild furbearer management and conservation in North America. Ontario Trappers Association, North Bay, Ont.

Jonkel, C. J., and R. Demarchi. 1984. Subdivisions and grizzly bears: a matter of jurisdiction. Western Wildlands 10: 24-27.

Johnson, C. 2002. Use of Resource Selection Functions to Predict the Distribution of woodland caribou habitat in northcentral British Columbia. Forest Research, Prince George Forest Region, Prince George, British Columbia.

Keith, L. B., and D. C. Surrendi. 1971. Effects of fire on snowshoe hare population. Journal of Wildlife Management 35: 16-26.

Kelly, G. M. 1977. Fisher (*Martes pennanti*) biology in the White Mountain National

Forest and adjacent areas. Ph.D. Thesis, Univ. Massachusetts, Amherst.
Kelsall, J. P. 1981. Status report on the wolverine, *Gulo gulo*, in Canada in 1981. COSEWIC report, Ottawa.
Kemp, G. A., and L. B. Keith. 1970. Dynamics and regulation of red squirrel (*Tamiasciurus hudsonicus*) populations. Ecology 51: 763-779.
Ketcheson, M. V., T. F. Braumandl, D. Meidinger, C. Utzig, D. A. Demarchi, and B. M. Wikeem. 1991. Interior cedar-hemlock zone. Pages 167-181 *in* D. Meidinger and J. Pojar, editors, Ecosystems of British Columbia. B.C. Ministry of Forests, Victoria.
Koehler, G. M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology 68: 845-851.
Koehler, G. M. 1991. Snowshoe hare, *Lepus americanus*, use of forest successional stages and population changes during 1985-1989 in north-central Washington. Canadian Field-Naturalist 105: 291-293.
Koehler, G. M., and K. B. Aubry. 1994. Lynx. Pages 74-98 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors, The scientific basis for conserving forest carnivores. American marten. Fisher, lynx, and wolverine in the Western United States. USDA, Forestry Service General Technical Report RM-254.
Krebs, J. A., and D. Lewis. 1998. Wolverine ecology and habitat use in the North Columbia Mountains, B.C. Progress report available at: http:www.wolverinefoundation.org/research/krebs2.htm
Krebs, J. A., and D. Lewis. 2000. Wolverine ecology and habitat use in the North Columbia Mountains: Progress Report. Pages 605-703 *in* L. M. darling, editor, Proceedings Conference on the Biology and Management of Species and Habitats at Risk. Vol. 2, B.C. Ministry Environment, Lands and Parks and University College of the Cariboo, Kamloops.
Krohn, W. B., S. M. Arthur, and T. F. Paragi. 1994. Mortality and vulnerability of a heavily trapped fisher population. Pages 137-145 *in* S. W. Buskirk, A. Harestad, M. Raphael, and R. A. Powell, editors, Martens, sables, and fishers: biology and conservation. Cornell Univ. Press, Ithaca, N.Y.
Krohn, W. B., K. D. Elowe, and R. B. Boone. 1995. Relations among fishers, snow, and martens: development and evaluation of two hypotheses. The Forestry Chronicle 71: 97-105.
Krohn, W. B., C. L. Hoving, D. J. Harrison, D. M. Phillips, and H. C. Frost. 2003. *Martes* foot-loading and snowfall distribution in eastern North America: implications to broad-scale distributions and mesocarnivore interactions. *In* D. J. Harrison, A. K. Fuller, and G. Proulx, editors, *Martes* in human altered landscapes. Proceedings 3rd International *Martes* Symposium, University of Maine, Orono: *in press.*
Krohn, W. B., W. J. Zielinski, and R. B. Boone. 1997. Relations among fishers, snow, and martens in California: results from small-scale spatial comparisons. Pages 211-232 *in* G. Proulx, H. N. Bryant, and P. M. Woodard, editors, *Martes*: taxonomy, ecology, techniques, and management. Proceedings 2nd *Martes* Symposium, Provincial Museum of Alberta, Edmonton.
Landa, A., O. Strand, J. D. C. Linnell, and T. Skogland. 1998. Home-range sizes and altitude selection for arctic foxes and wolverines in an alpine environment. Canadian Journal of Zoology 76: 448-457.

Lee, J., and A. Niptanatiak. 1996. Observation of repeated use of a wolverine, *Gulo gulo*, den on the tundra of the Northwest Territories. Canadian Field-Naturalist 110: 349-350.

LeFranc, M. N., Jr., M. B. Moss, K. A. Patnode, and W. C. Sugg, III. Editors. 1987. Grizzly bear compendium. Interagency Grizzly Bear Committee, Bozeman, Montana.

Leonard, R. D. 1980. The winter activity and movements, winter diet and breeding biology of the fisher (*Martes pennanti*) in southeastern Manitoba. M.Sc. Thesis, university of Manitoba, Winnipeg.

Litvaitis, J. A., J. A. Sherburne, and J. A. Bissonette. 1985. Influence of understory characteristics on snowshoe hare habitat use and density. Journal of Wildlife Management 49: 866-873.

Lofroth, E. C. 2001. Wolverine ecology in Plateau and Foothill landscapes 1996-2001. British Columbia Wildlife Branch, Forest Renewal Activity # 712260.

Magoun, A. J. 1985. Population characteristics, ecology, and management of wolverines in northwestern Alaska. Ph.D. Thesis, University of Alaska, Fairbanks.

Magoun, A. J., and J. P. Copeland. 1998. Characteristics of wolverine reproductive den sites. Journal of Wildlife Management 62: 13113-1320.

McLellan, B. N., and F. W. Hovey. 2001a. Natal dispersal of grizzly bears. Canadian Journal of Zoology 79: 838-844.

McLellan, B. N., and F. W. Hovey. 2001b. Habitats selected by grizzly bears in a multiple use landscape. Journal of Wildlife Management 65: 92-99.

McLellan, B.N. and D.M. Shackleton. 1988. Grizzly bears and resource-extraction industries: effects of roads on behavior, habitat use and demography. Journal of Applied Ecology 25:451-460.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia. B.C. Ministry of Forests, Victoria.

Meidinger, D., J. Pojar, and W.L. Harper. 1991. Sub-boreal spruce zone. Pages 209-221 *in* D. Meidinger and J. Pojar, editors, Ecosystems of British Columbia. B.C. Ministry of Forests, Victoria.

Monthey, R.W. 1986. Responses of snowshoe hares, *Lepus americanus*, to timber harvesting in northern Maine. Canadian Field-Naturalist 100: 568-570.

Mountain Caribou Technical Advisory Committee (MCTAC). 2002. A strategy for the recovery of mountain caribou in British Columbia. B.C. Ministry Water, Land and Air Pollution, Victoria. Mimeograph.

Mowat, G., K.G. Poole, D.R Seip, D.C. Heard, R. Smith, and D.W. Paetkau. 2002. Grizzly and Black Bears Densities in Interior British Columbia. FRBC Workplan No. OPM 01103, Activity No. 720869 and Common Land Information Base Project No. CLB01029.

Myrberget, S. 1968. The breeding den of the wolverine, *Gulo gulo*. Fauna 21: 108-115 (in Norwegian with English summary).

Nordyke, K. A., and S. W. Burkirk. 1991. Southern red-backed vole, *Clethrionomys gapperi*, populations in relation to stand succession and old-growth character in the central Rocky Mountains. Canadian Field-Naturalist 105: 330-334.

Ognev, S. I. 1935. Mammals of USSR and adjacent countries. Vol. 3: Carnivora (Fissipedia and Finnipedia). Israel Program Sci. Translation, Jerusalem,1962.

Ontario Ministry of Natural Resources. 1988. Timber management guidelines for the

provision of moose habitat. Ontario Ministry of Natural Resources, Toronto.
Paragi, T. F., S. M. Arthur, and W. B. Krohn. 1996. Importance of tree cavities as natal dens for fishers. Northern Journal of Applied Forestry 13: 79-83.
Pearson, A. M. 1975. The northern interior grizzly bear *Ursus arctos* L. Canadian Wildlife Service Report Series No. 34.
Peek, J. M. 1997. Habitat relationships. Pages 351-373 *in* A. W. Franzmann and C. C. Schwartz, editors, Ecology and management of the North American moose. Smithsonian Institution Press, Washington.
Peek, J. M., M. R. Pelton, H. D. Picton, J. W. Schoen, and P. Zager. 1987. Grizzly bear conservation and management: a review. Wildlife Society Bulletin 15: 160-169.
Peek, J. M., D. L. Urich, and R. J. Mackie. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildlife Monograph No. 48.
Pendergast, B. A. 1969. Nutrition of spruce grouse of the Swan Hills. M.Sc. Thesis, University of Alberta, Edmonton.
Pietz, P. J., and J. R. Tester. 1983. Habitat selection by snowshoe hares in North Central Minnesota. Journal of Wildlife Management 47: 1335-1343.
Poole K.G., D. C. Heard, and G. Mowat. 2000. Habitat use by woodland caribou near Takla Lake in central British Columbia. Canadian Journal of Zoology 78: 1552-1561.
Potvin, F., L. Bélanger, and K. Lowell. 2000. Marten habitat selection in a clearcut boreal landscape. Conservation Biology 14: 844-857.
Powell, R. A. 1977. Hunting behavior, ecological energetics and predator-prey community stability of the fisher (*Martes pennanti*). Ph.D. Thesis, Univ. Chicago, Illinois.
Powell, R. A. 1993. The fisher. Life history, ecology, and behavior. Second edition. University of Minnesota Press, Minneapolis.
Powell, R. A., and W. J. Zielinski. 1994. Fisher. Pages 38-73 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors, The scientific basis for conserving forest carnivores. American marten, fisher, lynx, and wolverine in the Western United States. USDA, Forest Service General Technical Report RM-254, Fort Collins, Colorado.
Powell, S. M., E. C. York, J. J. Scanlon, and T. K. fuller. 1997. Fisher maternal den sites in central New England. Pages 265-278 *in* G. Proulx, H. N. Bryant, and P. M. Woodard, editors, *Martes*: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alta.
Proulx, G. 1983. Characteristics of moose (*Alces alces*) winter yards on different exposures and slopes in southern Quebec. Canadian Journal of Zoology 61: 112-118.
Proulx, G. 2000. Habitat requirements of mammals in Canfor's Tree Farm Licence #30. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forest Products Ltd., Prince George, British Columbia.
Proulx, G. 2001. Characteristics and management of American marten habitat at stand and landscape levels. Alpha Wildlife Research & Management Ltd. report submitted to British Columbia Ministry of Forests, Prince George,.
Proulx, G. 2003. Potential options for the management of vertebrate species at risk in Canfor's planning areas. British Columbia Forest Investment Account project, Alpha Wildlife Research & Management Ltd. report submitted to Canfor, Prince George

Operations, and British Columbia Forest Investment Account, Victoria..
Proulx, G., K. B. Aubry, J. Birks, S. W. Buskirk, C. Fortin, H. C. Frost, W. B. Krohn, L. Mayo, V. Monakhov, D. Payer, M. Santos-Reis, R. Weir, and W. J. Zielinski. 2003. World distribution and status of the genus *Martes*. *In* D. J. Harrison, A. K. Fuller, and G. Proulx, editors, *Martes* in human altered landscapes, Proceedings 3rd International *Martes* Symposium: *in press.*
Proulx, G., and V. Banci. 2003. Martens and fishers as indicators of forest structural complexity in managed landscapes of west-central Alberta. *In* D. J. Harrison, A. K. Fuller, and G. Proulx, editors, *Martes* in human altered landscapes, Proceedings 3rd International *Martes* Symposium: *in press.*
Proulx, G., D. Bernier, and F. P. Caffrey. 2002. A field guide to species at risk in Canfor's Planning Areas in the north-central interior of British Columbia. Alpha Wildlife Research & Management Ltd., Sherwood Park, Alberta.
Proulx, G., D. Bernier, J. M. Heron, and K. A. Paige. 2003. A field guide to species at risk in the Coast Forest Region of British Columbia. Interfor and British Columbia Government, Queen's Printer, Victoria.
Proulx, G., and P. J. Cole. 1996. Fisher population status: Robson Valley. Alpha Wildlife Research & Management Ltd. report submitted to Columbia Fish & Wildlife Compensation Program, Nelson, British Columbia, 36 pages.
Proulx, G., and R. Joyal. 1981. Forestry maps as an information source for description of moose winter yards. Canadian Journal of Zoology 59: 75-80.
Proulx, G., and R. Kariz. 2001a. Occurrence of American marten and other furbearers in TFL # 30, Prince George Forest District. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forest Products Ltd., Prince George, Forest Renewal British Columbia Agreement Number 2000-FRBC-49.
Proulx, G., and R. Kariz. 2001b. Moose winter habitat in Canfor's Operating Area in Lakes Forest District, British Columbia, 1999-2001. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forest Products Ltd., Houston.
Proulx, G., and R. Kariz. 2001c. Occurrence of American marten and other furbearers within a connectivity corridor network, in Canfor's Morice T.S.A. 20, November 2001. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forest Products Ltd., Houston, British Columbia. 20 pages.
Proulx, G., and R. Kariz. 2002. Using forest cover maps to predict American marten distribution in the SBS and ICH biogeoclimatic zones of the Prince George Forest District, British Columbia. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forest Products Ltd., Prince George, Forest Renewal British Columbia Agreement Number F103519-01.
Proulx, G., A. Kolenosky, M. Badry, R. Drescher, K. Seidel, and P. Cole. 1994. Post-release movements of translocated fishers. Pages 197-203 *in* S. W. Buskirk, A. Harestad, M. Raphael, and R. A. Powell, editors, Martens, sables, and fishers: biology and conservation. Cornell Univ. Press, Ithaca, N.Y.
Proulx, G., and R. Verbisky. 2001. Occurrence of American marten and other furbearers within a connectivity corridor network, in Canfor's Morice T.S.A. 20. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forest Products Ltd., Houston, British Columbia. 26 pages.
Proulx, G., and V. Vergara. 2001. Wildlife habitat attributes for wildlife tree patch

quality assessment in Canfor's managed landscapes. Alpha Wildlife Research & Management Ltd. report submitted to Canadian Forests Products Ltd., Prince George, British Columbia.
Pulliainen, E. 1968. Breeding biology of the wolverine (*Gulo gulo*) in Finland. Ann. Zool. Fenn. 5: 338-344.
Rae-Chute, M. 1999. BC's Endangered Mountain Caribou. British Columbia Environment Report 10 (1): 24-25.
Raine, R. M. 1983. Winter habitat use and responses to snow cover of fisher (*Martes pennanti*) and marten (*Martes americana*) in southeastern Manitoba. Canadian Journal of Zoology 61: 25-34.
Ramcharita, R. K. 2000. Grizzly bear use of avalanche chutes in the Columbia Mountains. M.Sc. Thesis, University of British Columbia, Vancouver.
Raphael, M. G. 1988. Long-term trends in abundance of amphibians, reptiles, and mammals in Douglas-fir forests of northwestern California. Pages 23-31 *in* R. C. Szare, K. E. Severson, D. R. Patton, editors, Management of amphibians, reptiles, and small mammals in North America. USDA, Rocky Mountain Forest Range Experimental Station, General Technical Report, RM-166.
Rausch, R. L., and A. M. Pearson. 1972. Notes on the wolverine in Alaska and the Yukon Territory. Journal of Wildlife Management 36: 249-268.
Rosenberg, K. V., and R. G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas-fir forests. Pages 263-272 *in* J. Verner, M. L. Morrison, and C. J. Ralph, editors, Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. University of Wisconsin, Madison.
Rothwell, R. 1979. Nest sites of red squirrels (*Tamiasciurus hudsonicus*) in the Laramie range of southeastern Wyoming. Journal of Mammalogy 60: 404-405.
Rowe, J. S. 1972. Forest regions of Canada. Department Fisheries and Environment, Canadian Forest Service, Publication No. 1300.
Roy, K. D. 1991. Ecology or reintroduced fishers in the Cabinet Mountains of northwest Montana. M.Sc. Thesis, Univ. Montana, Missoula.
Rusch, D. A., and W. G. Reeder. 1978. Population ecology of Alberta red squirrels. Ecology 59: 400-420.
Schallenberger, A., and C. J. Jonkel. 1980. Rocky Mountain East Front grizzly studies. 1979. University of Montana, Border Grizzly Project, Special Report 39.
Schmidt, K., and S. McNay. 2002. Wolverine, Chase, Finlay and Scott Caribou Herds ungulate winter range (UWR). Final Report. Mackenzie, British Columbia.
Seip, Dale. 2002. Ecological relationships between threatened caribou herds and their habitat in the Central Rocky Mountains Ecoregion. FRBC Research Project # OPR02001-01.
Serebryakov, V. F. 1984. The glutton lairs in Bolshezemelsky tundra. Zoologicheskii Zhurnal 63: 953-955 (In Russian with English summary).
Servheen, C. W. 1981. Grizzly bear ecology and management in the Mission Mountains. Ph.D.. Thesis, Univ. Montana, Missoula.
Simpson, K., J. P.Kelsall, and M. Leung. 1994. Integrated management of mountain caribou and forestry in southern British Columbia. 6th North American Caribou Workshop, Prince George, British Columbia, Pp. 153-158.
Soulé, M. E., and J. Terborgh, editors. 1999. Continental conservation. Scientific

foundations of regional reserve networks. Island Press, Washington, D.C.
Stevenson, S. K., H. M. Armleder, M. J. Jull, D. G. King, B. N. McLellan, and D. S. Coxson. 2001. Mountain caribou in managed forests: recommendations for managers. British Columbia Ministry of Environment, Lands and Parks, Wildlife Branch, Wildlife Report No. R-26.
Stevenson, S., H. M. Armleder, M.J. Jull, D.G. King, E.L. Terry, G.S. Watts, B. N. McLellan, and K.N Child. 1994. Mountain Caribou in Managed Forests: Preliminary Recommendations for Managers. Ministry of Environment, Lands, and Parks Wildlife Branch, Victoria, B.C.
Stroganov, U. 1969. Carnivorous mammals of Siberia. Israel Program Sci. Translation, Jerusalem.
Sullivan, T. P., and R. A. Moses. 1986. Red squirrel populations in natural and managed stands of lodgepole pine. Journal of Wildlife Management 50: 595-601.
Terry, E. L., B. N. McLellan and G. S. Watts. 2000. Winter habitat ecology of mountain caribou in relation to forest management. Journal of Applied Ecology. 2000, 37, 589-602.
Terry, E. L., B. McLellan, G. S. Watts, and J. Flaa. 1994. Early winter habitat use by mountain caribou in the north central and Columbia Mountains, British Columbia. 6th North American Caribou Workshop, Prince George, British Columbia, Pp. 133-140.
Tevis, L., Jr. 1956. Responses of small mammal populations to logging of Douglas-fir. Journal of Mammalogy 37: 189-196.
Thomas, J. W., Editor. 1979. Wildlife habitats in managed forests. The Blue Mountains of Oregon and Washington. USDA Forest Service, Agriculture Handbook No. 553.
Thomasma, L. E., T. D. Drummer, and R. O. Peterson. 1994. Modeling habitat selection by fishers. Pages 316-325 *in* S. W. Buskirk, A. Harestad, M. Raphael, and R. A. Powell, editors, Martens, sables, and fishers: biology and conservation. Cornell Univ. Press, Ithaca, N.Y.
Thompson, I. D. 1988. Habitat needs for furbearers in relation to logging in boreal Ontario. The Forestry Chronicle 65: 251-261.
Thompson, I. D., and R. W. Stewart. 1997. Management of moose habitat. Pages 377-401 *in* A. W. Franzmann and C. C. Schwartz, editors, Ecology and management of the North American moose. Smithsonian Institution Press, Washington.
Vahle, J. R., and D. R. Patton. 1983. Red squirrel cover requirements in Arizona mixed conifer forests. Journal of Forestry 81: 14-15, 22.
Verme, L. J. 1965. Swamp conifer deer yards in northern Michigan, their ecology and management. Journal of Forestry 63: 523-529.
Vroom, G. W., S. Herrero, and R. T. Ogilvie. 1977. The ecology of grizzly bear winter den sites in Banff National Park, Alberta. 4th International Conference on Bear Research and Management, Kalispell, Montana.
Waller, J. S., and R. D. Mace. 1997. Grizzly bear habitat selection in the Swan Mountains, Montana. Journal of Wildlife Management 61: 1032-1039.
Weir, R. D. 1995. Diet, spatial organizations, and habitat relationships of fishers in south-central British Columbia. M.Sc. Thesis, Simon Fraser Univ., Burnaby, B.C.
Weir, R. 2000. Ecology of fishers in the sub-boreal forests of north-central British Columbia: Year IV (1999/2000) – Radiotelemetry monitoring and habitat sampling. Report no. 222, Peace/Williston Fish and Wildlife Compensation Program, Prince

George, B.C.
Weir, R. 2003a. Wolverine. *Gulo gulo*. Draft species account for Identified Wildlife Management Strategy, Victoria.
Weir, R. 2003b. Status of fishers in British Columbia. B.C. Ministry of Water, Land and Air Pollution report, Victoria: *in press*.
Weir, R. D., F. B. Corbould, and A. S. Harestad. 2003. Effect of ambient temperature on the selection of rest structures by fishers. *In* D. J. Harrison, A. K. Fuller, and G. Proulx, editors, *Martes* in human altered landscapes. Proceedings 3rd International *Martes* Symposium, University of Maine, Orono: *in press.*
Weir, R. D., and A. S. Harestad. 2003. Scale-dependent habitat selectivity by fishers in south-central British Columbia. Journal of Wildlife Management 67: 73-82.
Weir, R., A. S. Harestad, and F. B. Corbould. 2003a. Home ranges and spatial organizations of fishers in central British Columbia. *In* D. J. Harrison, A. K. Fuller, and G. Proulx, editors, *Martes* in human altered landscapes. Proceedings 3rd International *Martes* Symposium, University of Maine, Orono: *in press.*
Whitman, J. S., W. B. Ballard, and C. L. Gardner. 1986. Home range and habitat use by wolverines in southcentral Alaska. Journal of Wildlife Management 50: 460-463.
Wolfe, M. L., N. V. Debyle, C. C. Winchell, and T. R. McCabe. 1982. Snowshoe hare cover relationships in northern Utah. Journal of Wildlife Management 46: 662-670.
Wood, Mari D. 1994. Seasonal habitat use and movements of woodland caribou in the Omineca Mountains, north central British Columbia, 1991-1993. 6th North American Caribou Workshop, Prince George British Columbia, Canada. Pp. 365-377.
Youngman, P. M. 1975. Mammals of the Yukon Territory. National Museum of Natural sciences of Canada, Publ. Zool. 10.
Zager, P. E., and C. J. Jonkel. 1983. Managing grizzly bear habitat in the northern Rocky Mountains. Journal of Forestry 81: 524-526, 536.
Zyryanov, A. N. 1989. Spatial distribution, feeding and reproductive behavior of wolverine in Siberia. Byulleten' Moskovskogo Obshchestva Ispytatelei Prirody Otde Biologicheskii 94: 3-12 (In Russian with English summary).

APPENDIX I

Recommendations for the Management of American marten (Proulx 2001)

Martens inhabit forest mosaics where stands have the following attributes: 1) a developed multi-storied canopy cover offering overhead protection, and 2) ground structural complexity including large-diameter coarse woody debris and a developed understory. Martens usually are associated with mesic coniferous mature and old growth stands. Landscapes dominated by late-successional stands are more valuable to marten than those dominated by early-seral stages. Martens are very sensitive to landscape fragmentation. The maximum amount of openings (natural and anthropogenic) that martens can tolerate in their home range is about 30%. The arrangements and linkages between stands are important for marten that exhibit great reluctance to cross openings or venture very far from overhead cover.

The impact of logging on marten results from the removal of overhead cover, the loss of large-diameter coarse woody debris, and, in the case of clearcutting, the conversion of mesic sites to xeric sites, with associated changes in prey communities. However, selective and patch cuts that retain at least 20 m^2/ha basal area in large trees that provide a canopy closure of at least 30%, are used by martens.

On the basis of state-of-the-art information on marten habitat requirements and response to habitat changes and previous habitat management strategies, the following recommendations should be considered:

- Landscape level
  - Timber harvest should represent < 50% of landscape units.
  - Structure within the cut blocks should be maintained through the retention of large snags and coarse woody debris, and particularly with ≥ 2 ha wildlife tree patches with stands that are suitable for marten.
  - At least 50% of the managed landscape should remain uncut in order to provide martens with continuous forest patches.
  - Fragmentation (measured as the percent of the landscape unforested due to natural openings, and natural and anthropogenic disturbances) should be < 30% of the marten habitat area. If logging is permitted, it should occur every 80 years in 0.1-1.0 patches.
  - Within clearcuts and between forest patches, a network of connectivity corridors should be maintained to allow marten movements within and between harvested and uncut areas.

- Stand level
  - Coniferous (e.g., pure spruce), mixed-coniferous (e.g., spruce-fir, spruce-pine, pine-spruce, pine-fir, etc.), and mixed coniferous-deciduous (e.g., spruce-aspen) stands. Pure pine stands may be acceptable if overhead and ground structure is present with mesic conditions, or if surrounding stands offer poor habitat conditions to martens.

- Mature (variable age, closed even canopy, trees usually ≥ 20 cm dbh) and old (variable age, with mortality of tall and large canopy trees, canopy gaps, large snags, and large downed woody debris).
  Note: On the basis of Proulx and Kariz (2002), minimum dbh should be 27.5 cm and age class ≥ 7 (> 120 years old).
- Circum-mesic (i.e., submesic, mesic, subhygric).
- Canopy closure ≥ 30%.
- ≥ 20 m^2/ha basal area in trees ≥ 20 cm [*sic* – 27.5 cm] dbh.
- Presence of ≥ 30-cm-dbh snags and CWD (some ≥ 20 cm diameter).
- Developed understory with > 20%, but preferably > 40%, horizontal and vertical cover.

Recommendations for the Management of Mountain Caribou (Stevenson et al. 2001)

Mountain caribou make elevational movements in response to factors such as snow conditions, forage availability, and predation pressure. During early winter, they use the ICH and ESSF zones. During late winter, Mountain Caribou nearly always use the upper ESSF and adjacent parkland habitats. They consistently show a preference for old forests and an avoidance of young stands.

At the regional and landscape levels, habitat management for caribou includes:

- Ensuring that large contiguous areas of habitat are maintained in a suitable condition for use by caribou;
- Providing linkage areas to ensure connectivity among caribou populations centers;
- Controlling access and human activity – especially backcountry winter recreation – in caribou ranges; and
- Separating caribou from predation by avoiding the enhancement of moose, deer and elk (*Cervus elaphus*) populations near caribou habitat.

At the stand level, the overall goal for caribou habitat management is to maintain a stand that is suitable for use by caribou continuously through time. Both single-tree selection and group selection have the potential to maintain caribou habitat, provided the level of removal (< 30%) and entries are infrequent (e.g., once every 80 years).

The following prescriptions produce stands that are being used by caribou.

Prescriptions for Group Selection:

- ≤ 30% volume removal on an area basis, including skid trails.
- 80-year cutting cycle.
- Openings should be 0.1 to 1.0 ha, with a mean opening size ≤ 0.5 ha.
- Shape of the openings can vary to incorporate natural clumps of trees within the stand while allowing efficient skidding.
- Distribute openings throughout the block so that the second and third entries can also be well distributed.
- Keep openings at least 2 tree lengths apart where possible.
- Retain standing dead trees within the safety regulations of WCB.

- Harvest carefully to minimize damage to residual stems.

Prescriptions for Single-tree Selection:

- ≤ 30% volume removal on an area basis, including skid trails.
- 80-year cutting cycle.
- Generally, basal area of live trees should not be < 20-25 m^2/ha.
- Minimize the amount and width of skid trails, e.g., minimum 40 m apart and maximum 4-5 m wide.
- Retain standing dead trees within the safety regulations of WCB.
- Harvest carefully to minimize damage to residual stems.

Recommendations for the Management of Moose (Proulx 1983, Ontario Ministry of Natural Resources 1988,Thompson and Stewart 1997)

Individual components of moose habitat include: areas of abundant high-quality winter browse; shelter areas that allow access to food; isolated sites for calving; aquatic feeding areas; young forests with deciduous shrubs and forbs for summer feeding; mature forests that provides shelter from snow or heat; and mineral licks. Most previous studies suggest that the juxtaposition of food and shelter in late winter can be an important and possibly limiting factor of moose habitat. When snow is deep, moose select its habitat on the basis of cover characteristics and topographical features. In montane areas, moose move down to overwinter in river bottoms vegetated with preferred foods (primarily willow).

In the boreal forest, logging should be planned to produce mosaics of early-, mid- and late-seral stages, with buffer zones between cut blocks (80-130 ha) and residual stands, movement corridors, etc. (Fig. A.1)

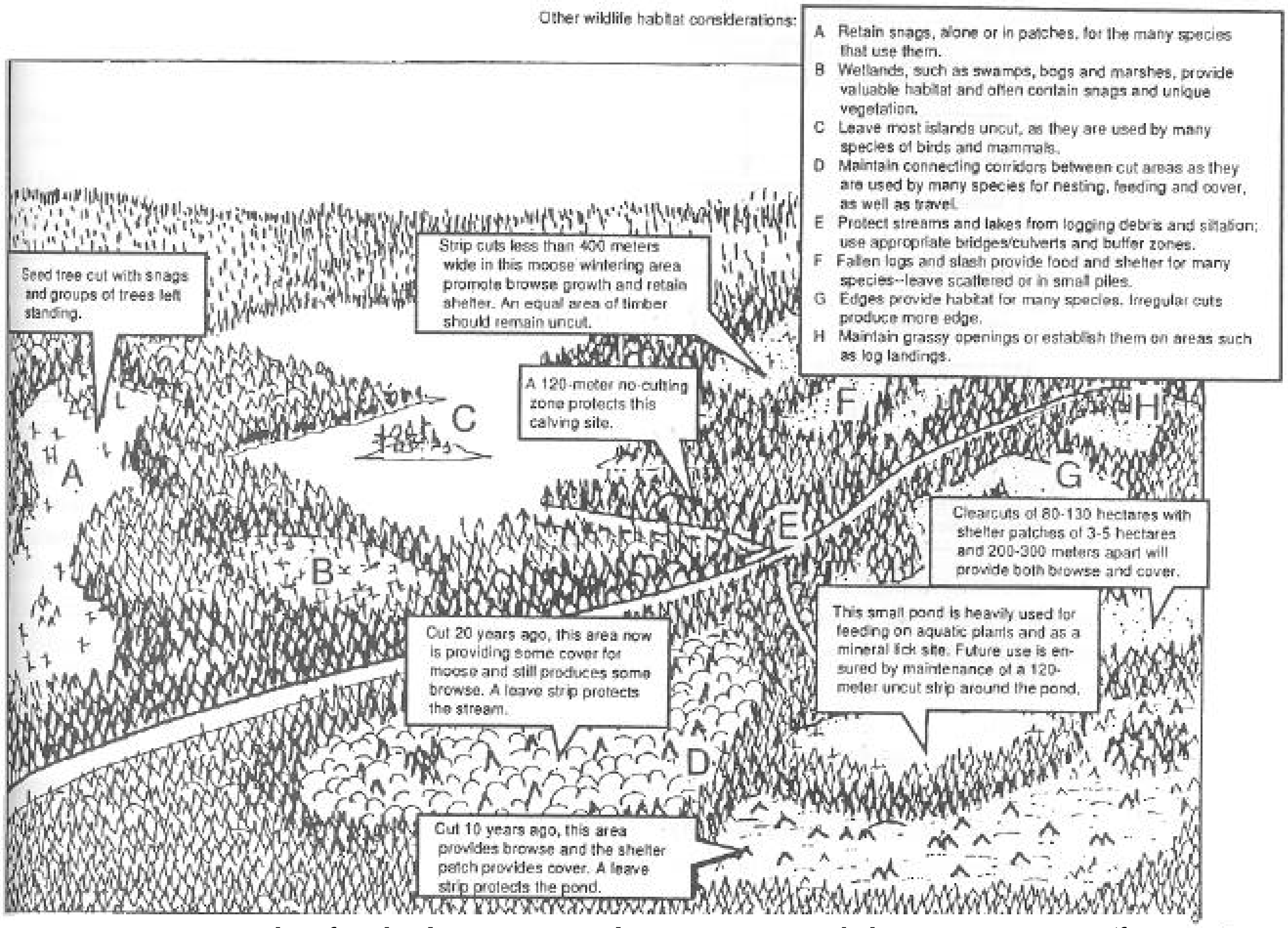

Figure A.1. Example of a landscape managed to meet moose habitat requirements (from Thompson and Stewart 1997)