Wolverine Ecology and Habitat Use in the North Columbia Mountains: Progress Report

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ABSTRACT

We are currently completing a multiyear project investigating demography and habitat use of a harvested population of wolverine (Gulo gulo) in a 7,000-km² area within the Kootenay region of British Columbia. The study area contains 10 registered traplines, 2 national parks, a major transportation corridor, 2 hydroelectric reservoirs, and active logging areas, and supports a substantial helicopter skiing industry. Wolverine are considered vulnerable by the British Columbia Wildlife Branch; consequently, vital rate data are important for evaluating management/conservation options. A total of 39 (14F, 25M) adult and subadult wolverine have been captured over 3,700 trap-nights using log-box traps baited with available road-killed wildlife. Population estimates for the core 4,000-km² study area based on 4 years of live-trapping data are 25.6 (95% CI: 15.6–55.3) and 24.0 (95% CI: 14.7–44.3) for 1996 and 1997 respectively. Six of 11 mortalities detected during the study to date have been human caused. Annual survival rate was estimated to be 0.77 (95% CI: 0.66–0.88) for all age and sex categories combined. Reproductive data are being gathered through radiotelemetry and follow-up ground investigations of breeding females after den abandonment. Three 2-kit litters have been produced in 14 adult female reproductive seasons. Four of these juveniles have been captured and implanted with radio transmitters. Natal den sites have been in the Engelmann Spruce–Subalpine Fir (ESSF) biogeoclimatic zone, and associated with woody debris and/or large boulder talus in undeveloped drainages. Home ranges of males ($\bar{\chi}$ = 1,005 km²) were significantly larger than those of females ($\bar{\chi}$ = 310 km²). At the study area scale, the distribution of wolverine use is highly clumped in 4 distinct utilization peaks. The 2 largest utilization peaks occur within Glacier and Mount Revelstoke national parks, disproportionate to their land base within the study area. The focus for the remainder of the project is on the monitoring of existing females and kits, and identification and characterization of natal dens in spring 1999. A population census using motion-sensitive cameras will be conducted March–April 1999. Final report and management recommendations will be completed in 2000–01.

Key words: Columbia Mountains, *Gulo gulo*, habitat use, population estimation, radiotelemetry, vital rates, wolverine.

Wolverine (*Gulo gulo*) have disappeared from almost half of their former range (Paquet and Hackman 1995). In Canada, COSEWIC (the Committee on the Status of Endangered Wildlife in Canada) has listed the eastern wolverine as Endangered and the western wolverine as Vulnerable, yet wolverine are the least known of Canada's large carnivores and conservation research needs are extensive (Hummel 1990). An understanding of vital rates is fundamental to the evaluation of conservation options.

In southeastern British Columbia and elsewhere in western Canada, persistence of wolverine and other wide-ranging carnivores depends on suitable habitat inside and outside protected areas. Pressures of human use in both protected and unprotected landscapes are important carnivore conservation issues, since potential mortality/fragmentation sources such as highways and railways, as well as disturbance/displacement agents such as human recreation, occur with increasing intensity within protected areas; and additional industrial (logging, hydroelectric generation, mining) and commercial (trapping, helicopter skiing) land uses occur in surrounding lands (Hummel 1990, Paquet and Hackman 1995).

Since wolverine are so wide ranging (home ranges 48–2,000 km²: Hornocker and Hash 1981, Magoun 1985, Whitman et al. 1986, Banci 1987, Hatler 1989), they present a problem of scale for managers and trappers alike. Wolverine do not exist in manageable numbers within individual traplines and, therefore, may be vulnerable to overharvest. In eastern Canada, increased human activity and development has resulted in declining wolverine populations and, subsequently, listing of the species as Endangered by COSEWIC (van Zyll de Jong 1975, Dauphine 1989). Western populations of wolverine may be heading in a similar direction if measures are not taken now to protect wolverine and wolverine habitat. The juxtaposition of national parks and transportation corridors, as well as resource extraction activities and commercial trapping, within our study area provides an opportunity to examine how these land uses influence wolverine vital rates. Specific objectives are:

1. Estimate vital (birth, death) rates for wolverine within the North Columbia Mountains (NCM) of southeastern British Columbia.
2. Identify landscape/habitat characteristics and human use activities that correlate with use by wolverine.
3. Develop a population model to estimate current and potential rates of increase of wolverine.
4. Produce biologically-based management recommendations for the conservation of wolverine in the NCM.

This report presents the initial results from the first 45 months of field activity up to 31 January 1999. Data analysis is not yet complete, but preliminary results are presented.

STUDY AREA

The project area (7,000 km^2) is located north of the Trans-Canada Highway between Revelstoke and Rogers Pass in the south and the Mica Dam in the north, and within Fish and Wildlife management units 4-37, 4-38, and 4-33 (Fig. 1). The core live-trapping area (4,000 km^2) consisted of the western portion of the area, along the eastern side of the Revelstoke reservoir. The area is within the Northern Columbia Mountains ecoregion; biogeoclimatic zones include Interior Cedar–Hemlock (ICH; vk1, wk1), Engelmann Spruce–Subalpine Fir (ESSFvc) and Alpine Tundra (AT).

The study area encompasses 10 registered traplines, portions of 2 national parks (Mount Revelstoke [MRNP], and Glacier [GNP]), 2 tree farm licenses, and several Forest License and Small Business Forest Enterprise Program cutting areas. Trappers harvest approximately 3 wolverine per year. The main valley bottom was inundated in 1985 with the construction of the Revelstoke Dam. The Kinbasket reservoir to the east and north was formed in 1973 with the construction of the Mica Dam. Other land uses include mining in Goldstream/French Creek, and heli-skiing, snowmobiling, and ski-touring at numerous locations throughout the area.

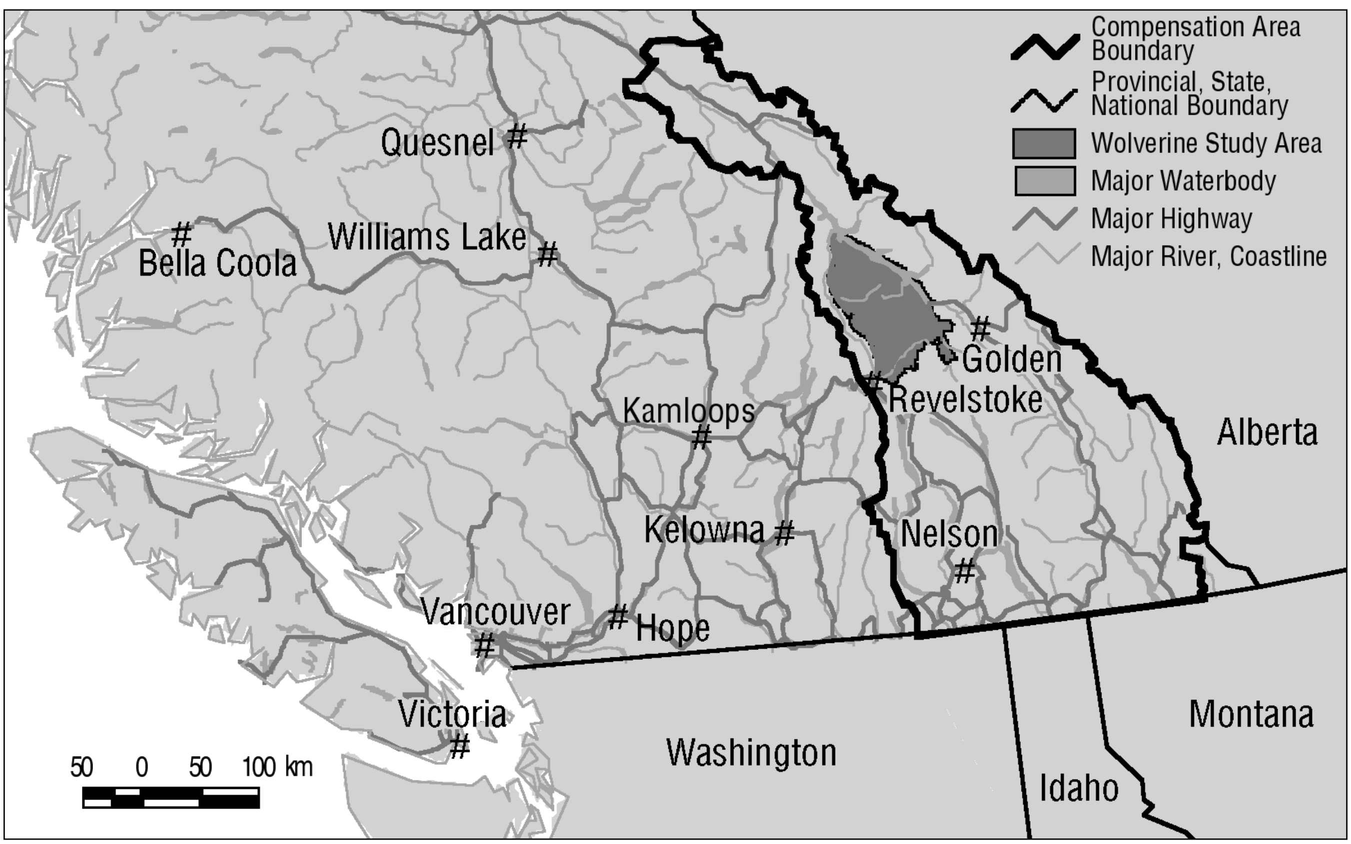

Figure 1. Location of the study area near Revelstoke, B.C.

METHODS

Live Trapping and Animal Handling

In consultation with local trappers, 33 log-cabin style and 7 portable (4 X 4 ft lumber) traps were constructed throughout the study area during 1994–97 to live-capture wolverine. Trap design was modified from Copeland et al. (1995) by using quick-release snaps as the trigger device and a bevelled front log on the door to improve fit when closed. Twenty-four traps were located in valley bottom ICHvk1 sites, 13 were within the ICHwk1, and 3 were placed in the ESSFvc. Four of the 40 traps were constructed within Mount Revelstoke and Glacier national parks. During the first winter we also used metal barrel traps (Banci 1987) opportunistically. Trapping effort was not even across the entire study area (Fig. 2), due to limitations of topography, access, and funding. Despite these limitations, our trapping effort resulted in 4 well-distributed "peaks" from north to south within the study area and was unbiased with respect to protected areas (Fig. 2).

Wolverine were immobilized with Telazol at 10mg/kg with a jabstick, ear-tagged with numbered rototags (NASCO, Modesto, CA), weighed, sexed, examined for reproductive status, and radio-collared (Lotek Engineering, Inc., Newmarket, ON; Telonics, Mesa, AZ, MOD-335). In order to minimize the chance of affecting guard hairs and underfur, a canvas insert designed to rot through after approximately 2 years was used to close the collar. The upper-left first premolar was extracted from most animals for aging purposes (Rausch and Pearson 1972). Cementum analysis was performed by Mattson's Lab in Montana.

Wolverine kits were captured at approximately 12–13 weeks of age by tracking reproductive females after emergence from natal dens. Kits were pursued on foot and immobilized after being spotted from a helicopter. Kits were surgically implanted with Telonics IMP300/L radio-transmitters under isoflourine anesthetic by an on-site veterinarian using a ventral midline procedure.

Mortality and Reproduction

Mortalities were detected via 4-hour-delay mortality sensors built into the radio-collar. We placed a high priority on recovering collars on mortality mode. Only cases where the radio-collar and the carcass were recovered were considered mortalities. Where only the collar was recovered it was

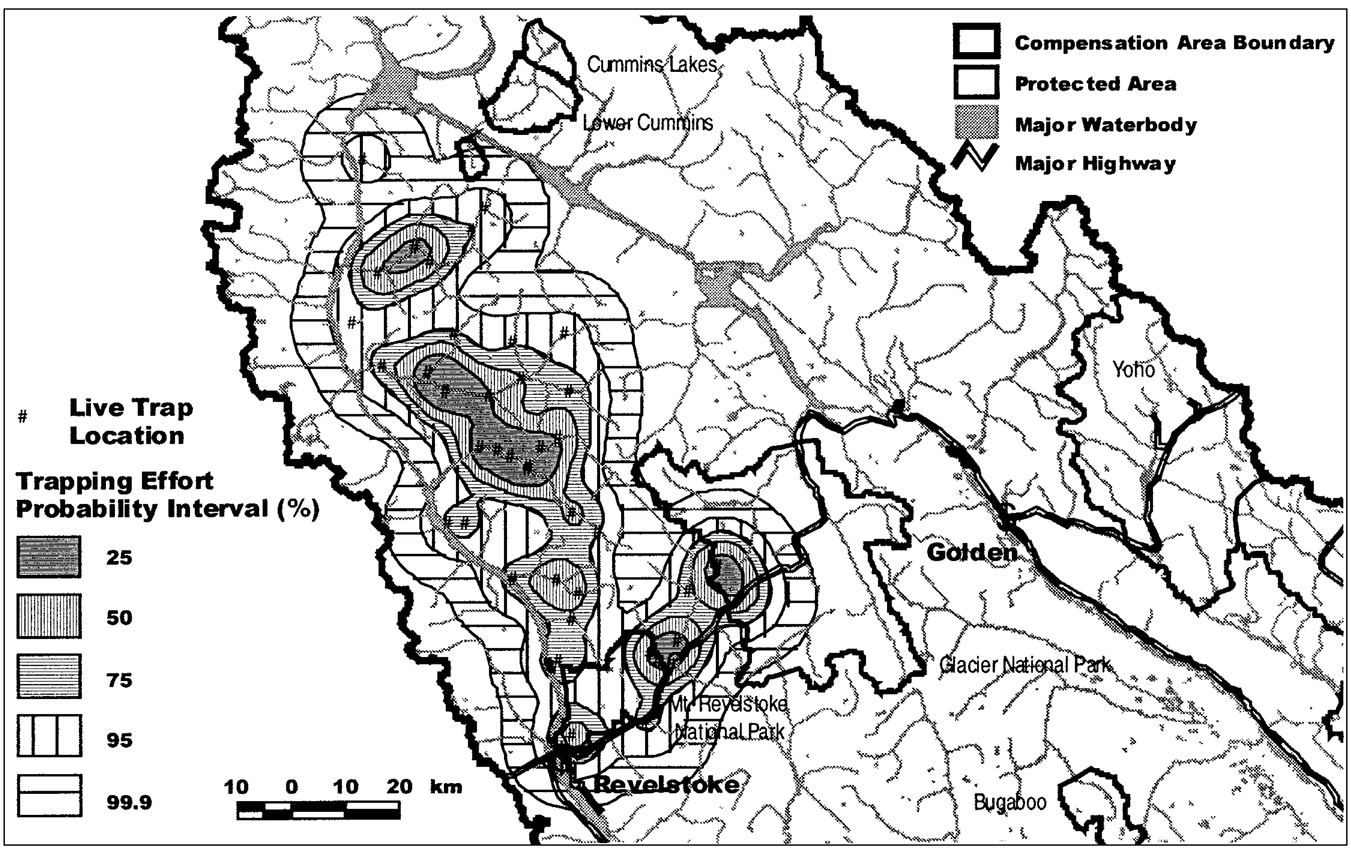

Figure 2. Adaptive kernal utilization distribution depicting live-trapping effort across the study area, 1995–98. Points correspond to trap locations.

coded as unknown. Where carcasses were recovered, a necropsy was performed by a veterinarian to determine cause of death. Survival rates were calculated following the approach outlined by Trent and Rongstad (1974) and Heisey and Fuller (1985), using program BOOTER (Hovey 1995), which bootstraps estimates to derive confidence intervals.

To confirm reproduction, radiotelemetry flights were intensified in March–late April to locate denning females. Females with identified dens were flown frequently (2 times per week or more) during May and June to increase the likelihood of obtaining visual observations of females with kits. We did not disturb den sites on the ground during the first 8–9 weeks of use to avoid potential displacement or abandonment of the site by the female.

Distribution and Habitat Use

Wolverine were located from the air using a Cessna 337 on a biweekly schedule. We attempted to locate females weekly during expected parturition dates (15 Feb–30 Apr) to establish natal den site locations. Location data collection followed that of McLellan and Flaa (1993) and included: UTM coordinates (NAD 27); forest cover polygon label (species, age, height, crown closure); habitat type (7 categories); biogeoclimatic subzone; elevation; aspect; slope; and activity of animal (if discernible). Location data precision was assumed to be ±100 m.

Location data have been presented at 2 scales: 1) as individual animal MCP (Minimum Convex Polygon) home ranges; and 2) as a representation of wolverine activity (i.e., all animals pooled) within the study area. This is useful in highlighting key locales, presumably of greatest importance to wolverine. Final habitat use analyses will treat individual wolverine separately for comparisons following multivariate procedures outlined by Aebisher et al. (1993) and Manly et al. (1993).

POPULATION ESTIMATION

Live-trapping data were used to derive an open population estimate (Seber 1982) for the 4,000-km² core of the study area. Each year (1995–98) was treated as a capture session in the analysis, confidence intervals were calculated following Manly (1984). An independent estimate using baited motion-sensitive cameras is planned for spring 1999.

RESULTS

Captures

Thirty-nine wolverine (14F, 25M) were live-trapped a total of 94 times in 3,700 trap-nights over 4 winters. Trapping success varied by trap type and month. Success was highest using wooden traps in February and March. Males were approximately 30% heavier than females (males 12.5 kg, n = 25, SD = 1.6; females 9.4 kg, n = 14, SD = 0.7). Ages are not yet available. Four 12-week-old male kits were also captured and implanted with radio-transmitters. Kits weighed 5.5 kg (n = 4, SD = 0.2).

Table 1. Reproductive history of radio-collared female wolverine, 1995–98. Ages determined by premolar tooth cementum analysis or estimated: subadult ≤2 yr; adult >2 yr. (D = den established but no kits survived post-weaning; DU = den established, unknown if kits survived post weaning; U = unknown; N = no reproduction; S = subadult (nonreproductive); Y (#,sex) = kits survived post-weaning.)

Wolverine	Age at capture	1995	1996	1997	1998
F204	9 (adult)	DU			
F206	1 (subadult)	S	S	N	D
F213	adult		N	N	N
F219	adult		U		
F222	adult		DU	DU	N
F223	1 (subadult)		S		
F227	subadult			S	
F228	adult			Y(2)	Y(2M)
F229	adult			Y(2M)	N
F235	subadult				S
F236	adult				N
F239	subadult				S
F241	1 (subadult)				S
F242	subadult				S
	Total adults	1	2	5	6
	Total kits	0	0	4	2
	Kits per adult	0	0	0.8	0.33

Mortality

A total of 11 radio-collared animals have died during the study: 4 were commercially trapped (M207, M217, M246, F206); 1 was killed on the Trans-Canada Highway in GNP (M212); 1 was killed on the Canadian Pacific Rail line in GNP (F223); 2 died of natural causes (F204, F229); and 2 were killed by other predators (M230, M208). One male (M224) died as a result of injuries received from either a fall or being kicked by a moose. At least 3 additional wolverine that had lost their radio-collars have also been commercially trapped (M201, F219, M232), and 1 other ear-tagged animal was recovered by backcountry skiers in MRNP (M209). Using only the radiotelemetry-located mortalities, annual survivorship for all collared wolverine up until January 1999 was 0.77 (95% CI: 0.66–0.88). The estimate for females only was similar (0.74, 95% CI: 0.55–0.93). Kit survival was slightly lower (0.61, 95% CI: 0.21–1.0), but is based on a limited sample size.

Reproduction

Three litters of 2 kits each have been produced over 14 adult female reproductive seasons (Table 1). Limited data suggest

Table 2. Characteristics of natal dens used by radio-collared wolverine, 1995–98.

Wolverine	Year	Status[a]	Dates occupied	Elevation (m)	Habitat	Structure
F204	1995	U	23 Feb–1 May	5,400	slide path	wood debris
F206[b]	1998	U	5 Apr–4 May	5,000		
F222	1996	U	13 Mar–13 Apr	5,400	mid-slope bench/ avalanche slope	wood debris
F222	1997	U	12 Mar–12 May	6,000	mature forest	wood debris
F228	1997	C	12 Mar–15 May	5,100	slide path	wood debris
F228	1998	C	16 Mar–4 May	4,900	slide path/ boulder	boulder/wood debris
F229[b]	1997	C	1 Apr–12 May	4,500		

[a] U = unconfirmed, kits not observed; C = confirmed, kits observed.
[b] Not yet ground-truthed.

reproductive rates varied greatly between years (Table 1). Females used dens during 5 seasons, but either did not produce young that survived to weaning age, or young were not detected. During the remaining 6 seasons females did not establish dens. Estimated parturition dates for the 3 litters were 1 March, 15 March, and 30 March. Characteristics and use of dens is described in a subsequent section.

Characteristics of Natal Dens

Four suspected and 3 confirmed natal den sites were found between 1995 and 1998 (Table 2). All dens were found within roadless, tributary valleys in the ESSFvc biogeoclimatic subzone under woody debris or a combination of woody debris and large boulders. Females occupied dens as early as late February and used them until mid-May in some cases. Den sites were not re-used in subsequent years. Four of the 7 den sites were located in national parks.

Home Range Size and Habitat Use

Home ranges (Table 3) of males (1,005 km^2) were significantly greater than those of females (311 km^2; $t_{1,18} = 2.85, P < 0.01$). Subadult males had larger average home ranges than adult males (1,611 km^2 vs. 601 km^2; $t_{1,8} = 2.18, P = 0.058$), whereas subadult female home ranges did not differ significantly from those of adult females (274 km^2 vs. 335 km^2; $t_{1,8} = 0.66, P = 0.27$). Male home ranges appear to overlap those of 1 or more females and those of other males, while ranges of females are exclusive except for accompanying young of the year and, in some cases, nonbreeding subadults. Home range boundaries were defined by geographic features (e.g., watercourses) and manmade features (e.g., reservoir, highway). Three animals crossed the Trans-Canada Highway at least 4 times; 1 was struck and killed.

Use of available habitat differed between males and females ($G = 68.7$, df = 2, $P < 0.005$) and by season. In winter, males used ICH habitats proportionately more than expected (Fig. 3; $G = 126.6$, df = 2, $P < 0.001$), whereas females used ESSF habitats more (Fig. 3; $G = 61.0$, df = 2, $P < 0.001$). In summer, males spent more time in ESSF habitats, while females used higher-elevation AT habitats (Fig. 3). The effects of human activities and land use have not been analysed.

Distribution of Animal Use Within Study Area

Between January 1995 and October 1998, 1,256 radiotelemetry locations were obtained from 43 individual radio-collared/implanted animals. Figure 4 depicts an adaptive kernal utilization distribution analysis of these locations. Four clear "peaks" in use (25% probability contour) are

Table 3. Home range analysis results for 10 male and 10 female wolverine using 100% Minimum Convex Polygon (MCP) method.

Males	Age class[a]	No. of locations	Home range (km^2)	Females	Age class[a]	No. of locations	Home range (km^2)
M202	A	81	689.5	F206	A	96	405.7
M203	A	59	875.4	F213	A	104	520.1
M208	A	50	568.9	F222	A	84	270.3
M214	A	67	369.8	F228	A	80	150.2
M224	A	30	754.8	F229	A	54	443.7
M225	S	39	874.3	F235	S	23	472.7
M226	S	22	1636.1	F236	A	39	217.9
M233	S	24	2884.3	F223	S	24	149.1
M237	S	25	1049.7	F241	S	17	204.3
M240	A	26	347.3	F242	S	31	271.2

[a] A = adult; S = subadult.

Table 4. Capture matrix and results for Jolly-Seber population estimate based on wolverine live-trapping data 1995–98.

	1995	1996	1997	1998
Captures	13	15	13	18
Recaptures				
1995		4	2	
1996			4	3
1997				6
Population estimate		25.6	24	
(95% CI)		(15.8–55.7)	(14.7–43.1)	

evident; the largest is located in Glacier National Park, followed by Mount Revelstoke National Park, Bigmouth/Windy Creek (north), and Downie/Goldstream (centre). Overlay techniques clearly demonstrate that high-use areas ("peaks") are found in protected areas in greater proportion than expected based on relative trapping effort and total park area. Protected areas comprise approximately 20% of the study area and include approximately 11% of the high trapping-effort area (25% contour), but contain >68% of the high-use area (Figs. 2 and 4).

Population Size

A Jolly-Seber mark–recapture estimate of population size using live-trapping data yielded estimates of 25.6 and 24.0 (Table 4) for the 4,000-km² core study area in 1996 and 1997 respectively. We did not correct for partial residency of animals (Garshelis 1992). Estimates suggest that approximately 50% of the wolverine population was marked during the census interval.

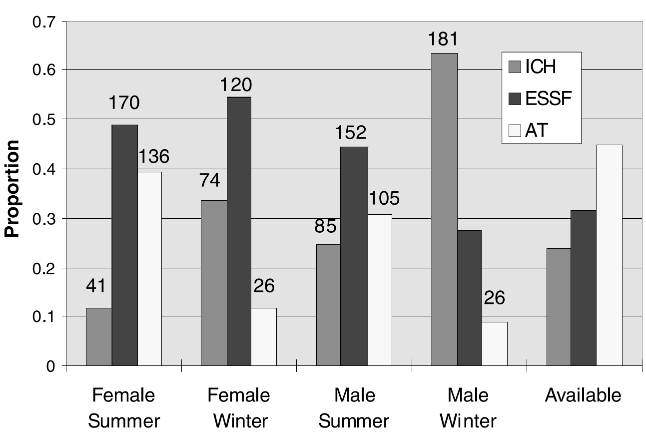

Figure 3. Seasonal habitat use of male and female wolverine by biogeoclimatic zone. (ICH = Interior Cedar–Hemlock; ESSF = Engelmann Spruce–Subalpine Fir; AT = Alpine Tundra.) Results were pooled among individuals for analysis.

DISCUSSION

Estimates of vital rates are essential to assess population growth or decrease (e.g., grizzly bears: Eberhardt et al.1994, Hovey and McLellan 1996, Mace and Waller 1997) and to aid in establishing sustainable harvests. To our knowledge, field estimates of wolverine survival are not available and reproductive rate data are scant. Banci (1994) summarized numbers of mortalities reported in radiotelemetry studies, but these were not reported as rates. Magoun (1985) suggested that annual survivorship would need to be ≤0.906 for a hypothetical wolverine population in NW Alaska to be stationary or stable. Our estimate of 0.77 falls well below this threshold, which may indicate a decline. Closer examination of the assumptions used in the Alaskan analysis will be required to determine if this is the case. In Idaho, Copeland (1996) documented a reproductive rate of 0.67 kits/female/year; Magoun (1985) in NW Alaska reported 0.69 kits/female/year. Our present estimate of 0.43 kits/female/year is lower, but is based on a low sample size. Differences arise through strong year effects, presumably related to food availability. In 1997 we had 2 litters from 5 adult females, whereas in 1998 only 1 litter was produced from 6 females. These rates are well below the averages reported using corpora lutea, placental scars, and fetus counts from carcasses (Rausch and Pearson 1972, Liskop et al. 1981, Banci and Harestad 1988). However, early survival of neonates may be low during periods of food stress. Lactation is known to be the most energetically demanding period for females. For wolverine this would correspond to the 15 February–30 April period. During years with poor carrion availability, reproductive females may fail to meet the high energetic demands of lactation and lose their litters (Magoun 1985). This could explain why some females in our study established what appeared to be natal dens but were never observed with kits after den abandonment. Since rates derived from carcasses do not capture the critical stage of preweaning kit survival, field estimates provide a better estimate of realized reproductive rate. At the conclusion of the project, reproduction and survival data will be used to explore potential rates of increase for our study population.

Reproductive females established dens in areas with little or no human disturbance, below treeline under avalanche debris or large boulders. Although at the stand or patch scale all dens located to date have been found in nonforested habitats similar to those reported by Magoun and Copeland (1998), our data differ when viewed at the landscape scale. Results clearly suggest that the upper-elevation forested zone (ESSFvc), not the alpine/parkland zone, is most used for denning. Additional factors, such as human activity, distribution of prey/carrion, and presence of other predators, likely affect the suitability of an area as denning habitat, but have not yet been investigated.

Carrion from avalanche-killed ungulates, other predator kills, and the presence of nutritionally stressed moose and goats likely explain the extensive use of valley-bottom ICH habitats by male wolverine during winter. Females also made greater use of the ICH in winter than summer; however, use of the ESSF zone was greatest. This may be partially an artifact of the location of reproductive dens. Copeland (1996) also recorded a seasonal shift in habitat use from montane forest types in winter to higher-elevation nonforested habitats in summer. Female wolverine in our study were frequently observed hunting and/or feeding on hoary marmot (*Marmota caligata*) during late spring and summer in alpine and subalpine habitats. Since wolverine operate at the landscape scale, with home ranges averaging 300 km^2 for females and 1,000 km^2 for males in our study area, habitat selection is unlikely to be strongly tied to stand or patch level attributes. Rather, habitat patch size, juxtaposition, and prey density/distribution may be more important factors. Final habitat use analysis will evaluate these factors in a GIS (geographic information system) environment.

Density estimates reported from published studies utilizing radiotelemetry and mean home range size tend to yield higher and more variable density estimates (1/65 km^2, Hornocker and Hash 1981; 1/48 km^2, Magoun 1985; 1/177 km^2, Banci 1987; 1/198 km^2, Copeland 1996) than those based on snow-tracking (1/207 km^2, Quick 1953; 1/193 km^2, Becker 1991). Whether these differences are related to the estimation techniques or actual differences in wolverine density is not certain. Our estimate (1/167 km^2) using 4 years of live-trapping information falls within the range of those reported above. A consistent problem in all the techniques employed is the relatively small study areas/high amount of edge, where estimates are derived that may inflate estimates significantly. This closure bias may artificially inflate estimates. The approach of Garshelis (1992), where telemetry data is used to adjust for animals who reside partly outside the census area, may provide a practical means for making more reliable estimates in small study areas; alternatively, larger census areas with less edge effect may be effective if used with track-based (Becker 1991), motion-sensitive cameras (Mace et al. 1994), or DNA-based methods (Woods et al. submitted) now being developed for grizzly bears.

The uneven distribution of wolverine use across the study area (Fig. 4) suggests that habitat quality is not equal across

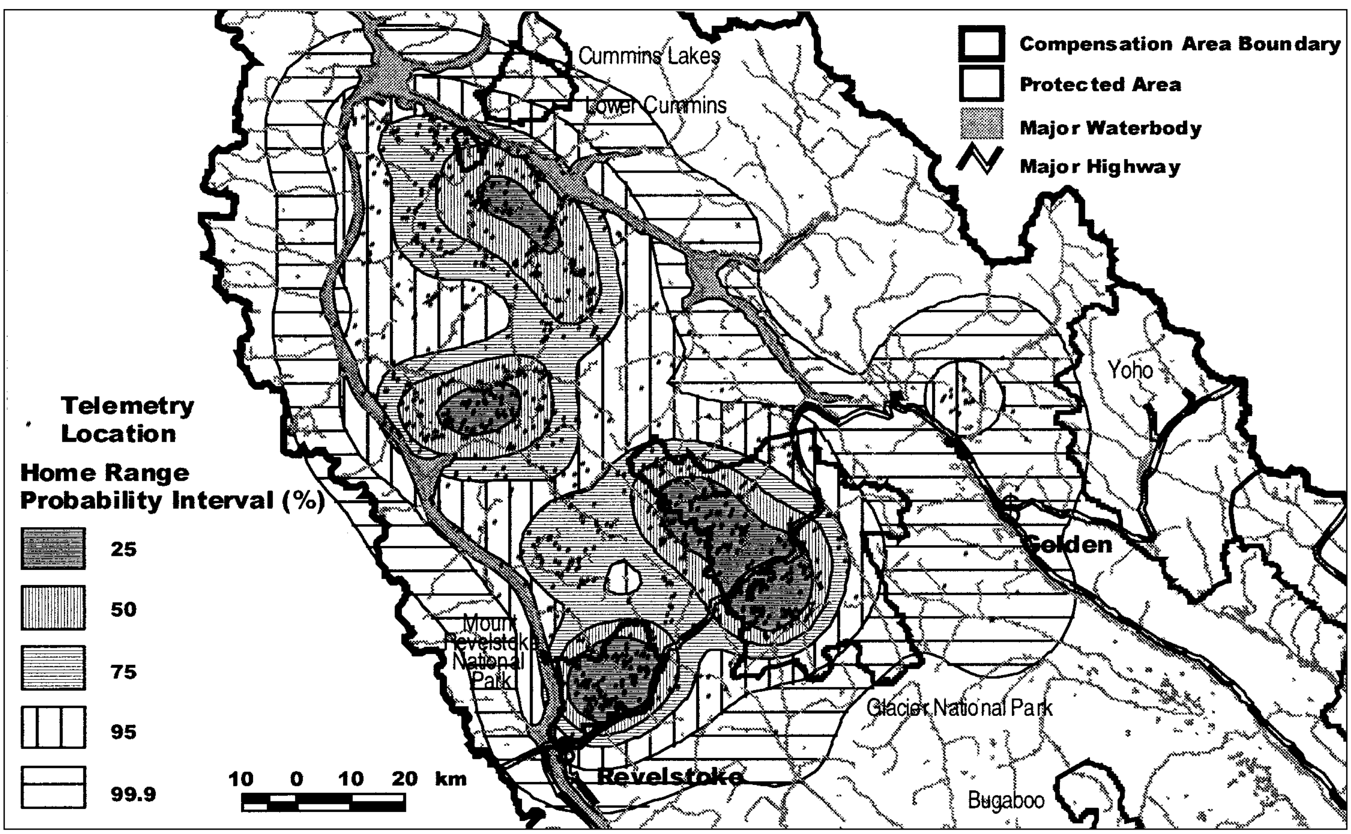

Figure 4. Adaptive kernal utilization distribution of all wolverine telemetry locations, 1995–January 1999. High-use areas show up as dark grey.

the area. The 2 largest "peaks" in use are centred on Glacier and Mount Revelstoke national parks. The Upper Bigmouth/Windy Creek "peak" area appears to support a high proportion of the wolverine population in the northern portion of the study area and may function as a refugium (Hatler 1989), similar to the national park areas. There is strong evidence that considerable movement occurs between Bigmouth Creek watershed and Windy and several smaller tributaries (Trident Creek; 2 unnamed creeks), which drain into Kinbasket reservoir. At present, most of this area is a defacto wilderness with access only in Bigmouth Creek. The high-use area located in the Downie/Goldstream area includes Nightmare Creek, 2 small Goldstream River tributaries, and the upper portions of Granite and Long creeks, which drain into Downie Creek.

MANAGEMENT IMPLICATIONS

Recommendations are preliminary at present, pending completion of field data collection.

1. Human-caused mortality of wolverine from trapping and transportation corridors is the largest factor influencing survivorship. Trapping restrictions may be warranted if rates are found to be unsustainable. Tracking sex and age of harvested animals through compulsory inspection would assist management decisions. Carrion along the road and rail right-of-ways needs to be disposed of rapidly to avoid collateral kill of carnivores such as wolverine.
2. National parks and unroaded wilderness areas appear to act as refugia at present. Pressures from commercial backcountry use, snowmobiling, and logging may erode the capacity of these areas to support wolverine, particularly reproductive females.
3. Maintenance of an abundant, diverse ungulate community is a necessary precursor to persistence of wolverine. Habitat and harvest management strategies that maintain moose, mountain goat, and caribou populations will benefit wolverine.

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