Northern Wolverine Project

Year End Final Report

Wolverine Ecology in Plateau and Foothill Landscapes 1996-1999

Eric C. Lofroth
Debbie Wellwood
William Harrower
Corinna Hoodicoff

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Executive Summary

The Northern Wolverine Project was initiated in 1996 to document the distribution and abundance of wolverine in plateau and foothill landscapes. The overall objective was to improve the basic ecological knowledge on wolverine in order to facilitate better science-based management. This year end report summarizes data collected from 1996 until March 1999. Selected data sets within the report contain more recent data.

The 8900 km^2 study area for the Northern Wolverine Project was established on the west side of Williston Reservoir in the Manson, Omineca, Osilinka and Mesilinka drainages. Four biogeoclimatic zones and 7 subzone/variants are represented within the study area. The study area contains considerable forest harvesting activity, major logging roads, a power transmission corridor, a hydro-eleoctric reservoir and sixteen registered traplines.

Thirty five different wolverine were live-trapped and instrumented with radio-transmitters (collars or implants) during the reporting period. Radio-instrumented wolverine were located on a weekly basis during the reporting period. Home ranges averaged 521.5 km^2 for adult females, 1756.1 km^2 for adult males, 1502.3 km^2 for subadult females and 3118.6 km^2 for subadult males. Adult females were located at higher elevations, on average, than all other sex and age classes during all seasons. They made substantial use of alpine and subalpine habitats, particularly when raising young. Primary food items during this period were caribou and marmots. Adult males and subadult females were found at high elevations during the breeding season. They and subadult males made substantial use of low elevation habitats at all other times of the year. Moose were the most common food type during these times. All sex and age classes used older aged forests far more than other successional stages. Snow trailing activity indices were greatest in the old growth successional stage.

Survivorship rates were 65% overall, with adult females having the highest rates (90%) and subadult males the lowest (20%). Sources of mortalities of monitored wolverine included trapping, con-specific mortality and natural causes. Five of 9 adult females monitored during this period had maternal dens in one or more years. Maternal dens were located in high elevation, subalpine cirques and talus slopes.

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1.0 Introduction

Wolverine (*Gulo gulo*) are uncommon to rare throughout most of British Columbia (Hatler 1989). The mainland subspecies (*G.g. luscus*) is on the provincial "Blue List" classifying it as vulnerable (CDC 2000). Vancouver Island Wolverine (*G.g. vancouverensis*) is on the provincial red-list (CDC 2000). Wolverine are classed as vulnerable by COSEWIC. Wide ranging forest carnivores such as wolverine and grizzly bears have been recognized as sensitive species provincially (CDC 2000; Hatler 1989), nationally (COSEWIC 1993) and internationally (Banci 1994) due to their large space requirements, low reproductive rates and poor juvenile survival. Populations of wolverine have declined dramatically in the continental US and Eastern Canada (Banci 1994), and Sweden (Linden et al. 1994) due to many factors including habitat loss, overharvest and a changing prey base.

Wolverine populations in British Columbia are managed as Class 2 furbearers (Hatler 1989) and legally harvested for their pelts. Class 2 furbearers are “those that move among and between traplines, are vulnerable to over-trapping, and generally not found in manageable numbers within a single registered trapline. In BC open trapping seasons for wolverine exist in BC Environment regions 3,4,5,6, and 7. There are no trapping seasons in regions 1,2, and 8. Wolverine may be particularly sensitive to over-harvest, due to their low densities and low reproductive rates. Provincial annual harvests ranged from a decade average low of 157.5/year (1990-1998) to a decade average high of 425.7/year (1970-1979) (Table 1). The harvest of the last decade has ranged from a low of 97 to a high of 236 (Table 2). No provincial population estimate exists for wolverine.

Table 1. Mean annual British Columbia wolverine harvest by decade (1920 – 1998)

Decade	Mean Annual Harvest
1920-1929	253
1930-1939	230
1940-1949	219
1950-1959	166.5
1960-1969	190.7
1970-1979	425.7
1980-1989	232.5
1990-1998*	157.5

* - data from 1999 is not yet available.

Table 2. Annual British Columbia wolverine harvest for 1990-1998.

Year	Harvest
1990	113
1991	127
1992	142
1993	236
1994	97
1995	186
1996	135
1997	230
1998	152

Banci (1994) summarized the available information for wolverine in North America. Much of what follows is a summary of her account. Wolverine are the largest member of the mustelid family. They range in average size from 9-10 kg (females) to 13-14 kg (males) on average. Adult males are typically 30%-40% heavier than adult females. Home ranges of adult wolverine range from 100 to 900 $km^{2.}$ This variability may be related to differences in abundance and distribution of food. Male home ranges are typically larger than those of females. Wolverine occur throughout a variety of habitats. They are found in boreal forests, tundra and the western mountains. Wolverine appear to do best in relatively undisturbed, remote mountainous areas (Banci 1994). Wolverine use habitats as diverse as old-growth forest and tundra. They may have an affinity for high elevations and a tendency for seasonal vertical migrations in mountainous areas. Wolverine habitat is probably best defined in terms of adequate year-round food supplies in large, sparsely inhabited wilderness areas, rather than in terms of particular types of topography or plant associations. Protected areas likely play a significant role in the conservation of this species. Connectivity of protected areas at a regional scale (between landscape units and protected areas) may be important in maintaining wolverine. Preferences for structural and other features of forest stands have been suggested to be related to food availability and temperature requirements. Overhead cover and structural features of forested stands may be important for natal and maternal dens.

Wolverine are active year round. Habitat use and energetic demands are likely most pronounced during winter. This is when food resources may be most concentrated. Nutritional demands are greatest in females while kits are nursing from early spring to summer. Wolverine are opportunistic feeders, thought to be primarily scavengers, but they spend considerable time hunting small and medium-sized prey. Large mammal (particularly ungulate) carrion is considered the most important part of their diet. Medium and small-sized mammals (ground squirrels, marmots, Snowshoe hare, porcupine, squirrels) become primary prey when carrion is not available. Ground-nesting birds (ptarmigan, grouse, waterfowl) seasonally comprise a part of their diet where available. Magoun (1987) described winter and summer food habits in Alaska in an area with a paucity of large herbivores in winter. Ground squirrels and caribou were the primary food items by weight with small mammals and birds a minor component. Ground squirrels were more prevalent in summer months, although were also fed upon in winter. Rausch and Pearson (1972) reported on a sample of 193 stomachs from trapped animals in Alaska and Yukon. 51% had empty stomachs, 14% had moose remains, 9% had caribou and 12% had snowshoe hare. Their sample was all winter specimens, however they speculated that ground nesting squirrels were important in summer. Gardner (1985) analyzed 35 colons from winter-killed wolverine in Alaska. Moose occurred in 24.7%, caribou in 20%, microtines in 20%, birds in 11.4%, squirrels in 8.6%, snowshoe hare in 5.7%, porcupine in 2.9% and beaver and muskrat in 2.9% of the samples. Based on foraging records for study animals, moose were less important in summer in his study area. At this time squirrels, birds and microtines were more important. Copeland (1996) analyzed 95 scats and 22 foraging site collections from wolverine in Idaho. Thirty-five percent of the samples were associated with natal and rearing dens of females. Ungulates (deer, elk and moose) were most common (44% occurrence in summer, 46% in winter). He reported little difference between winter and summer food habits. Banci (1987) sampled 411 stomachs from winter trapped wolverine in Yukon. She found an average of 1.3 prey types per stomach. Ungulates were present in 35.7%, snowshoe hare in 18.5%, and porcupine in 10.9% of samples. Ungulates were found in 38.8% of male stomachs and 30.3% of females. Vegetation was found in 49.6% of stomachs and 23.1% were empty. The only seasonal changes reported were in November where porcupine and snowshoe hare were more frequent than other months. Hatler (1989) in a summary of wolverine literature suggests that ungulates are highly important in winter diets with small mammals and birds of increasing importance at other times.

Because of the perceived importance of marmots as a food source to adult females in this study area, a pilot study was initiated in 1998 to determine hoary marmot habitat suitability and estimate marmot abundance in the alpine zone of the Northern Wolverine Project study area. Ennis (1998) summarizes the results from the habitat suitability objective of the study. Reid (1999) summarizes the results from the marmot abundance objective of the study and provides recommendations for both objectives in the 1999 field season. This report summarizes the 1998 and 1999 results of the study.

Reproductive rates are low in wolverine. Females breed for the first time at 1-2 years of age. Litter sizes range from 1 to 5. Litter sizes likely increase up to about an age of 6 years (Banci 1994). Pregnancy rates reach peak levels in the 3-6 year age classes and decline thereafter. Age of reproductive senescence is unknown. Juvenile mortality may be considerable and has been estimated at an average of 1.5 young/litter during the first summer. Reproductive rates are likely tied to the nutritional status of females.

There is a recognized need and demand for appropriate information on species which range over large areas, and exist in relatively low densities (Banci 1994, Lofroth et. al. 1996). Habitat management for these species will likely require actions on regional, landscape, and stand scales and as such require a hierarchical and comprehensive approach to research. Little information existed in BC for wolverine, particularly for demographics, population dynamics, movements, habitat use, foraging and food habits and reproduction. Less information existed on the effects of forest harvesting, roading and silviculture on these characteristics.

At present, inventory data are unavailable for wolverine in B.C. Forest management activities which influence prey populations, disturb denning areas and improve access for trapping may indirectly place considerable pressure on wolverine populations. In order to improve forest management decisions pertaining to wolverine, reliable techniques for assessing trends in population size need to be developed. This is especially important as wolverine were not considered in the Standardized Inventory Methods Manuals produced by the Resource Inventory Committee.

This research is designed to obtain important baseline movement, home range, habitat use, food habit and population information on wolverine in plateau and foothill landscapes and to develop reliable, cost-efficient methodologies for inventory. A similar, complimentary, research program (Krebs 1993) is being conducted to examine these parameters in interior mountainous environments in the southeast portion of BC. Considerable effort has been made to co-ordinate the research planning, design, methodology and implementation of these two projects so as to ensure compatibility of results. This will greatly increase the applicability of results.

The primary objective of this research program is to increase the knowledge base of wolverine ecology in BC and develop sound census methods for wolverine to ensure that habitat and population management programs are based in sound scientific information. As such our research objectives are:

- Examine seasonal habitat use and movement patterns of wolverine at regional, landscape and stand scales in plateau and foothill landscapes (SubBoreal Spruce, Spruce Willow Birch, Boreal White and Black Spruce, Engelmann Spruce Subalpine Fir and Alpine Tundra biogeoclimatic zones (Meidinger and Pojar 1991));
- Examine foraging patterns and food habits of wolverine, particularly as they relate to other predators and ungulate populations;
- Examine parameters of population dynamics including size, mortality and natality;
- Compare the above aspects of wolverine ecology with those of wolverine in Interior Wet Mountain Forests (Interior Cedar Hemlock, Engelmann Spruce Subalpine Fir zones).
- Developing genetic markers to enable DNA fingerprinting (microsatellite technique) of wolverine from hair follicle tissue.
- Field testing a variety of DNA collection methods.
- Estimating wolverine population size using the DNA technique in two ecologically distinct study areas (Revelstoke, Williston Reservoir).
- Recommending operational procedures for census of wide-ranging forest carnivores.
- Facilitating test of this methodology on an operational basis.

This report summarized data collected during the January 1996 to March 1999 period. Selected data sets contain more recent data. Development and testing of inventory methodologies will be summarized in a subsequent report.

2.0 Study Area

The study area is approximately 8900 km^2 in size and is located in the Omenica, Manson, Mesilinka and Osilinka River drainages of the Williston Reservoir basin in north-central British Columbia (Figure 1). The study area is in the Manson Plateau and Southern Omineca Mountains ecosections, and includes Sub-Boreal Spruce, Boreal Black and White Spruce, Spruce Willow Birch, Engelmann Spruce-Subalpine Fir, and Alpine Tundra biogeoclimatic zones (Meidinger and Pojar 1991) (Table 3; Figure 2). Elevations range from 675m to 2200m. The study area is contained within Natural Disturbance Type 3 - Frequent Stand Initiating Events - (MOF 1995). It has experienced considerable forest harvesting on its eastern periphery and in the northern half, particularly on the eastern half of the Butler Ranges, and the Mesilinka and Osilinka River drainages. The western and southern portions of the area (with the exception of the Manson River valley) have had relatively little forest harvesting. Major Forest Service Roads transect the study area on the west side of Williston Reservoir, and up the Manson, Mesilinka, Osilinka, Tenakihi, and Usilika Rivers, and Wasi Creek drainages. The study area is bounded on the east side by the Williston Reservoir impoundment of the W.A.C. Bennett Dam. An electrical transmission line parallels the major forest service road to the Kemess Mine. Sixteen registered traplines are contained in whole or in part within the study area. Reported annual wolverine harvests in the study area during the 1993 to 1997 period ranged from 0 to 4.

Table 3. Biogeoclimatic composition of the Northern Wolverine study area.

Zone	Subzone/Variant	Area (km^2)	Percent of Study Area
AT	P	1531.8	17.2
ESSF	MV3	3772.5	42.3
	MV4	45.8	0.5
SBS	MK1	364	4.1
	MK2	1351.2	15.2
	WK2	427.2	4.8
BWBS	DK1	1355.5	15.2
LAKE		64	0.7

The Alpine Tundra biogeoclimatic zone has the harshest climate of the study area (Pojar and Stewart 1991). Long-term average temperatures for this zone are likely below freezing. Much of the precipitation falls as snow and snow fall and drift accumulations can vary from as little as none on barren wind swept slopes to as much as 4-5 m in protected basins. Major vegetation bypes include krummholtz conifers, dwarf shrub, alpine grass, herb meadows and lichen and/or bare rock. The Engelmann Spruce Subalpine Fir zone occurs just below AT and just above SBS or BWBS within the study area. Climate is relatively cold and moist with much of the precipitation falling as snow (Table 3).

Table 4. Long term average snow depth (cm) for the Upper Germansen Snow Monitoring Station.

Month	Mean Snow Depth
January	83
February	97
March	114
April	122
May	109
June	38

Habitats are primarily coniferous forest dominated, with subalpine parkland/krummloltz at upper elevations. Tree species are dominated by Engelmann spruce and subalpine fir. Lodgepole pine is the common seral tree species. Two variants of the moist very cold subzone occur within the study area (Table 3). These are characterized by an ericaceous shrub layer, a sparse herb layer and a dense moss layer. Climate of the Sub-Boreal Spruce zone is characterized by severe snowy winters and relatively warm, moist short summers. Mean daily minimum and maximum average temperatures collected within the study area range from monthly lows of -38^{o}C to highs of 23^{o}C (Table 5). Daily snowfall and snow accummulation data are summarized in Table 6. Coniferous forests are dominated by hybrid white spruce and subalpine fir. Lodgepole pine, aspen, paper birch and cottonwood are common seral species. Black spruce occurs as a climax species in wet sites. Two subzones (moist cool and wet cool) with three variants occur within the study area (Table 3).

Table 5. Mean daily minimum and maximum recorded temperature ranges (by month) for SBS weather stations in the Northern Wolverine Project study area (^{o}C).

Month	Minimum	Maximum
September	5.15	15.1
October	-1.2	4.3 to 5.5
November	-18.7 to -6.4	-11.9 to 8.0
December	-15.1 to –12.8	-7.9 to –4.6
January	-38.8 to –16.7	-32.4 to –9.7
February	-17.0 to –9.5	-5.9 to –1.4
March	-12.9 to –6.8	-1.4 to 2.5
April	-3.8 to –2.5	5.5 to 8.6
May	3.8	19.6
June	6.8	23.0

Table 6. Mean daily snowfall (by month) and accumulated snowpack ranges for SBS weather stations in the Northern Wolverine Project study area (cm).

Month	Daily Snowfall	Snow depth
November	0.4 to 1.5	1.6 to 37.8
December	3.0 to 3.7	31.2 to 51.6
January	1.4 to 6.4	20.5 to 90.3
February	1.0 to 3.2	45.8 to 87.6
March	0.5 to 2.4	40.4 to 88.4
April	0 to 0.3	10.7 to 76.1

The Boreal White and Black Spruce zone occurs within portions of the Manson, Omineca, Oslinka and Mesilinka drainages. It's lower extent in these drainages is likely influenced by the extent of cold air drainage. This zone has long very cold winters and short growing seasons. Mean daily minimum average temperatures collected within the study area are as low as -44^{o}C (Table 7). Daily snowfall and snow accumulation data are summarized in Table 8. Major tree species within the study area are white spruce, black spruce, lodgepole pine, and balsam poplar. Only one subzone (dry cool) occurs within the study area (Table 3).

Table 7. Mean daily minimum and maximum recorded temperature (by month) ranges for BWBS weather stations in the Northern Wolverine Project study area (^{o}C).

Month	Minimum	Maximum
September	n/a	n/a
October	n/a	n/a
November	-22.8 to –9.7	-14.9 to –3.0
December	-19.7 to –19.0	-4.0
January	-44.0 to –33.0	
February	-11.6 to –8.0	-2.9 to 2.2
March	-12.2 to –10.4	-2.6 to 0.9
April	-6.6 to –6.3	2.8 to 7.2
May	n/a	n/a
June	n/a	n/a

Table 8. Mean daily snowfall (by month) and accumulated snowpack ranges for BWBS weather stations in the Northern Wolverine Project study area (cm).

Month	Daily Snowfall	Snowdepth
November	0.8 to 1.8	7.5 to 36.7
December	7.3	43.8 to 48.3
January		52.5
February	1.0 to 5.0	49.5 to 78.7
March	0.6 to 2.2	50.4 to 86.2
April	0.4	79.8

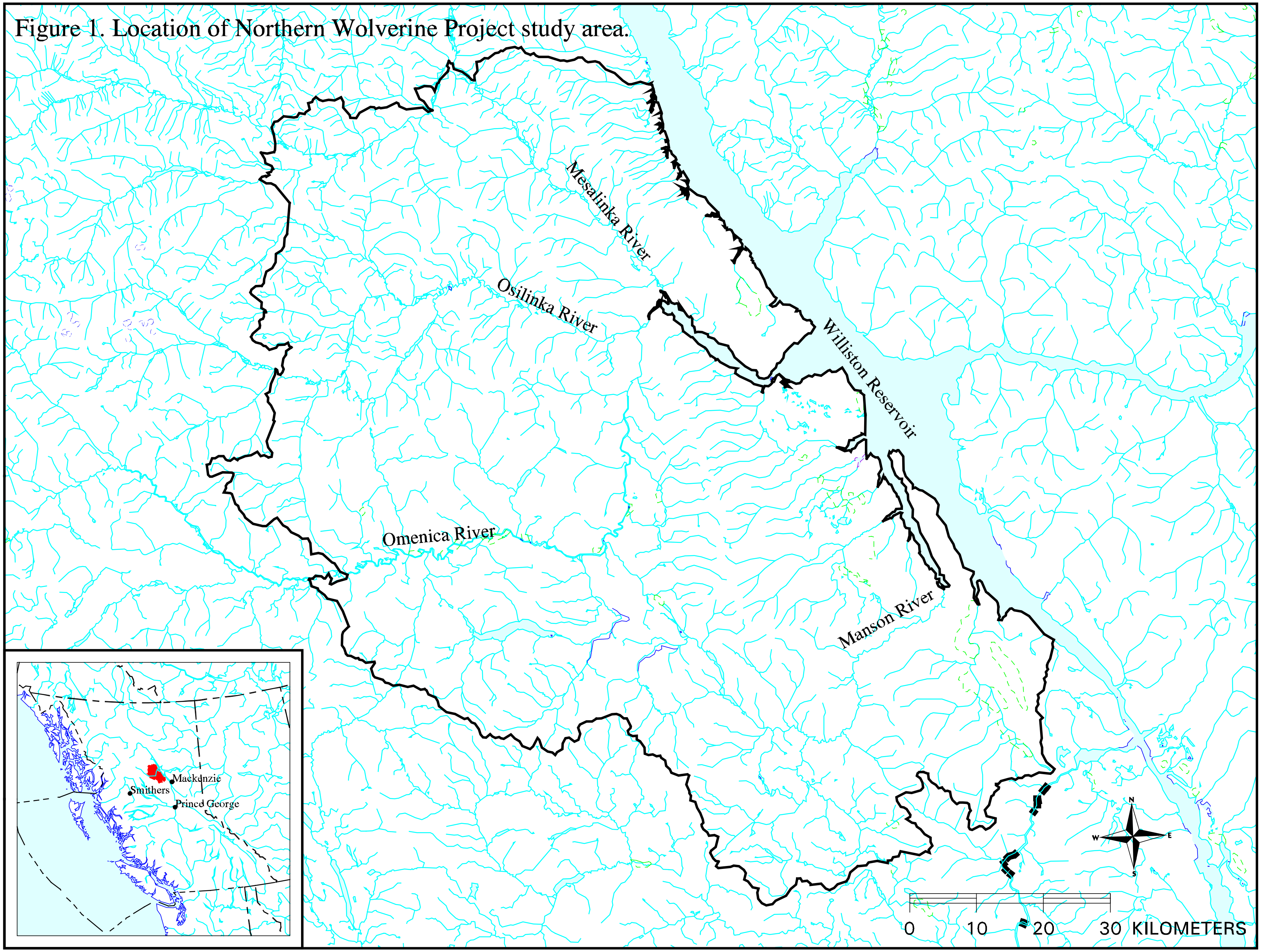


Figure 1. Location of Northern Wolverine Project study area.
Mesalinka River
Osilinka River
Williston Reservoir
Omenica River
Manson River
Mackenzie
Smithers
Prince George
N
S
E
W
0
10
20
30 KILOMETERS

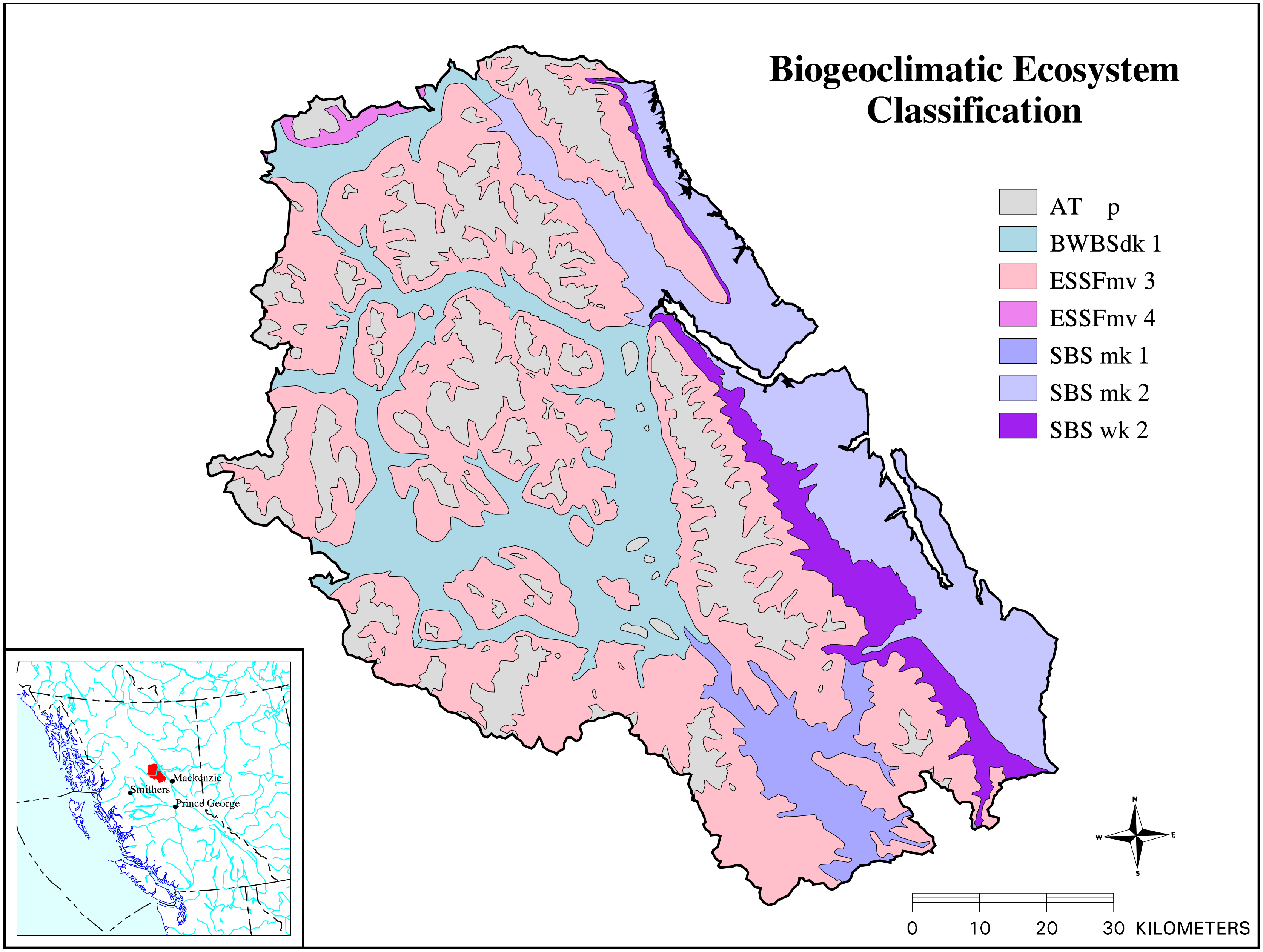


Figure 2. Biogeoclimatic ecosystem classification for the Northern Wolverine Project study area.

3.0 Methods

3.1 Capture and Handling

Wolverine were captured in log cabin traps constructed within the study area (Copeland et. al. 1995), and in portable barrel traps. The number of traps used varied between trapping sessions (Table 9).

Table 9. Number of traps used for trapping sessions.

Session	Log Cabin Traps	Barrel Traps
Fall 1996	29	3
Fall 1997	39	2
Fall 1998	24	1
Winter 1996	16	6
Winter 1997	37	6
Winter 1998	35	0
Winter 1999	24	0

Traps were set in riparian habitat, on ridge tops and in timbered corridors between cutblocks. All captured wolverine were immobilized, aged, sexed, weighed, measured and examined for tooth wear, evidence of lactation and scarring, and fitted with radio transmitters and numbered coloured ear-tags (Nasco Farm and Ranch Inc.). In 1996-1997, immobilizations were performed by trapping crews and wolverine were fitted with radio collars (Telonics MOD 335 equipped with mortality switches). In 1998, radio transmitter collars were abandoned in favor of radio transmitter implants (Telonics Model IMP-400). A veterinarian immobilized animals, implanted transmitters and supervised handling. Tissue samples were retained from ear-tag plugs in year 1 of the study to be used for DNA analyses for population methodology estimation. Hair samples were taken from all captured wolverine for the same purpose. Blood samples were taken from captured wolverine whenever possible, in years 2 and 3 of the study, for baseline serum documentation. Wolverine were allowed to fully recover within the live-traps before being released. Fisher were also captured in traps, and were processed in a similar manner as part of a concurrent study. Other non-target species captured were released from traps. All live-capture, handling and immobilization was conducted in accordance with BC Environment Animal Welfare Policy.

Most wolverine were immobilized with Telazol. Dosages were administered by pole syringe at a concentration of 10 mg/kg for the estimated weight of each animal. Immediately following immobilization, the upper left premolar was removed and coloured ear tags were fitted. Telazol was an insufficient anesthetic for the performance of the radio implantation surgeries. Isoflourine gas was used in these cases after an initial immobilization with Telazol. Gaseous isoflourine was used in a 1.5 to 3.0 percent mixture with oxygen, and was administered to effect. Isoflourine is an effective anesthetic for these procedures; however, as the Telazol had generally been metabolized by the animal, the moment that the gas administration ceased, the animal would begin to awaken. Following surgery, isoflourine was continued to allow completion of standard immobilization procedures such as morphometric measurements, tooth removal and ear tagging. If only a radio collar was fitted, physical measurements were made immediately following ear tagging, tooth removal and collar fitting. When possible, physiological responses of the animal were monitored throughout the immobilization.

Data collected were general information, pharmacological information, morphometric characteristics, and physiological information (Appendix 1). Physiological information, including respiration rates, heart rates, rectal temperature, and capillary response times were recorded. Data collection for these variables was sporadic, as it was not always possible to collect consistent information during the immobilizations. At some immobilizations no physiological information was collected, and at others a series of observations were made of all variables throughout the immobilization.

The reproductive status of female wolverines was assessed during spring capture sessions. Percentages of lactating females were determined by assessing whether females had rubbed or swollen nipples or were lactating.

3.2 Movement and Home Range

From March 1996 until March 1999 wolverine were radio-located once weekly when possible, using a Cessna 182 aircraft. Beginning in April 1999 the monitoring regime was changed from this extensive format to one of intensive monitoring during specific time periods corresponding to wolverine seasons (see section 4.3.1). During the maternal denning season female wolverine were located as often as every other day. Where access permitted, wolverine were monitored more intensively using ground based telemetry for portions of the year. Aerial location information included coordinates, broad ecosystem unit, forest cover, elevation, physical description and location accuracy (Appendix 2). Relocation flights were coordinated with those conducted to locate study populations of caribou, wolves and fisher in the same study area. Location data were analyzed using adaptive Kernel techniques (Worton 1989), utilizing the program Home Ranger (Hovey 1997).

3.3 Habitat Use

3.3.1 Landscape Scale

Landscape scale habitat use analyses were conducted using Bonferonni use/availability statistics (Neu et al. 1974). These analyses examine seasonal selection and habitat composition of home ranges by biogeoclimatic subzone and variant. Landscape scale habitat use also was evaluated by examining frequency distributions, which described relative use of biogeoclimatic zones and elevations over seasons. Habitat data and elevations of wolverine locations were documented during relocation flights.

3.3.2 Stand Scale

Stand scale habitat analyses were examined by analyzing selection of habitat within individual home ranges (Lofroth 1993), conducting site investigations at selected locations, and conducting snow-tracking surveys. Stand scale habitat data were collected at site investigations to describe structural characteristics of wolverine foraging, travel and denning habitat. Habitats were classified within biogeoclimatic zones to broad ecosystem unit (Province of BC 1998). Wolverines are wide-ranging and occur in relatively low densities, consequently the study area is very large. Therefore, wolverine locations were frequently difficult to access to conduct site investigations. As a result, site investigations of radio-transmittered wolverine were conducted opportunistically during snow tracking or following ground or aerial telemetry locations. Wolverine activity sites were accessed by helicopter, snowmobile, snowshoe or hiking. Site investigations were also conducted at wolverine activity sites as a result of snow-tracking or visuals of unknown wolverine. Opportunistic site investigations, conducted during snow-tracking, were primarily focused on activities other than travel (i.e. beds, kills, caches or feeding sites). During site investigations, the general area of the wolverine location was thoroughly searched for evidence of wolverine activity. In winter wolverines were fore-tracked and back-tracked from the location to determine the wolverine's activities. Habitat description forms were used to describe the location, habitat, terrain, vegetation and activity ***(***Appendix 3). Photographs were taken of representative habitats and evidence such as beds, dens and/or carcasses. All scats encountered were collected for food habits analyses.

All known maternal dens were located by aerial telemetry and accessed by helicopter. An initial brief investigation was made of the den while the den was active. Efforts were made to minimize disturbance of the area. All dens were visited at least once while there was still snow on the ground but after the female had left the area. Habitat description forms were used to describe the location, habitat, terrain, vegetation and wolverine activity. A den description form, including den measurements, was also completed (Appendix 4). Photographs were taken of the den and representative habitats. All scats observed were collected.

3.3.3 Snow Tracking

Stand scale habitat analyses were also examined by conducting snow-tracking surveys. Wolverine tracks were located during the months of November through March by visiting aerial locations of known wolverine or by opportunistic location of wolverine tracks during daily field work. Tracks were followed from the point of interception both forwards (fore-tracking in the direction of wolverine travel) and backwards (back-tracking in the opposite direction of wolverine travel) until tracking could not be continued due to physical barriers (e.g. open water), loss of tracks in bad conditions or loss of daylight. Data recorded during each session included length of track and straight line distance travelled, behaviours and activities observed, habitat types and site information. Activity indices were calculated as the ratio of actual distance travelled to straight line distance travelled. Wolverine were tracked opportunistically during the 1998/99 winter field season and systematically during winter 1999/2000. Data reported here include that collected up to and including December 1999.

3.4 Food Habits

Wolverine food habits were examined by analyzing the contents of scats collected in the course of the study and the stomachs of carcasses. Wolverine carcasses were submitted by trappers from the BC Environment Omineca/Peace and Skeena regions. Included in these analyses were those carcasses obtained from study animal mortalities. Carcasses were kept frozen until the time of necropsy. Stomachs were then removed and kept frozen until such time as contents could be processed. The stomachs were cut open and contents rinsed through a series of standard Canadian soil sieves with decreasing mesh size of 6.35, 5.6, 2.0 and 1.0 mm. Scats were soaked in water and also rinsed and sieved in the same manner. Stomach and scat contents were placed into petri dishes and dried in a fume hood for 24 hours. Samples were separated into animal guard hair, bone fragments, feathers and other components (vegetation, garbage etc.). Animal guard hairs were spread out onto a 100 grid cell sampling sheet. Hairs were sampled from 10 randomly selected grid cells. Guard hairs were placed on green acetate, sandwiched with two microscope slides, held together with bulldog paper clips and heated to soften the acetate (after Moore et al. 1974, Park 1991). Guard hairs were examined under a compound microscope. Medullae and scale structure of guard hairs were examined and compared with illustrations (Park, 1991), photographs (Moore et al. 1974) and slides of known specimens. Bones and feathers were identified, where possible, using reference collections from the University of Victoria Anthropology and Biology departments.

Foraging habits of study animals were examined by recording predation and scavenging information from wolverine radio-locations, and snow-tracking, site investigations and incidental observations.

3.5 Marmot Habitat Suitability

In 1998, a pilot study was conducted in two study areas. One study area was at the northern end of the Wolverine Range, and the other study area was at the southern end of the mountain range located on the western side of the Mesilinka River. In 1999, research was only conducted in the Wolverine Mountains study area. In 1999, the study area was located between the northern end of the Wolverine Mountains and Mount Porter to the south. The study area was within the Alpine Tundra (AT) and the upper edge of the Engelmann Spruce Subalpine Fir (ESSF) biogeoclimatic zones.

The methodologies used in the pilot study in 1998 were also used in 1999 and are provided in Reid (1999). In 1999, one change was made to the classification of talus in the habitat suitability methodology. The talus vegetation type was subdivided into three types, ribbon talus, extensive talus and un-vegetated, as recommended by Reid (1999). In 1998, observation polygons for marmot abundance were subjectively selected, and in 1999 observation polygons were randomly selected. In 1999, two people conducted 14 days of fieldwork between July 29 and August 11.

3.6 Population Parameters

Wolverine were live-captured in log cabin traps and fitted with radio-transmitters from January 1996 to March 1999. From March 1996 until March 1999 wolverine were radio-located once weekly when possible using a Cessna 182 aircraft. Beginning in April 1999 the monitoring regime was changed from this extensive format to one of intensive monitoring during specific time periods corresponding to wolverine seasons. Wolverine were monitored at least once every three weeks during the April to December 1999 time period. During the maternal denning season female wolverine were located as often as every other day. Where access permitted wolverine were monitored more intensively, using ground-based telemetry for portions of the year.

Vital population rate data collected included: natality, juvenile and adult survival, and mortality sources. Natality information was obtained by examining placental scars and corpora lutea (Banci and Harestad 1988) of carcasses of study animals and those submitted by trappers. Natality of study animals was examined by visits to maternal den sites and opportunistic observation of females with kits. Study animals whose transmitters switched to “mortality” mode were located and investigated as soon as possible. Survivorship rates reflect the known fate of known (radio-transmittered) wolverine only. They do not include data on additional known wolverine mortalities within the study area during this period. Survivorship of collared wolverine in the study area was calculated using staggered entry design Kaplan-Meier analysis (Pollock et al 1989).

4.0 Results and Discussion

4.1 Capture and Handling

4.1 Capture

A total of 35 individual wolverine were captured 82 times during seven capture sessions (Tables 10 and 11). Eighteen male and 17 female wolverine were captured, with the majority of female wolverines captured during the first two years of trapping. Seven were juveniles, nine were yearlings and nineteen were adults when captured. Some wolverine, such as W03, were recaptured as many as 10 times. Several traps were damaged by wolverines attempting to chew their way out. Some attempts at escape were successful, resulting in 4 captured animals escaping prior to processing. Two trap related mortalities occurred, one when a trap door closed onto a wolverine, breaking the animals back. This previously collared wolverine had to be euthanized. The second trap mortality occurred when a wolverine attempted to escape, and was caught between the trap door and the lower half of the trap, and was asphyxiated.

Wolverine were monitored for a variety of time periods (Table 10). This was as a result of problems with maintaining collars on wolverine. Properly fitting collars is difficult. A collar fitted too loose will be easily slipped and little data collected, a collar fitted too tight will abrade hair, and possibly skin, resulting in injury to the animal. Precautions taken when fitting collars meant that many animals shed their collars, along with additional collars lost due to premature release of the rot-a-way inserts. Some animals were monitored for as little as 3 months (W28). With the high costs and time investments in trapping wolverine, losing study animals due to premature breakage or slipped collars was unacceptable. Subsequent to this, many collars slipped over animals heads. These problems resulted in the change to the use of surgically implanted transmitters. Implants have not been in use long enough to evaluate their true effectiveness; however, early results show only small oscillations in signal strength and increased reliability of data collection.

Capture success was influenced by weather conditions (Table 12). Wolverine capture successes were poorest in very cold temperatures. Capture successes were greater (although not significantly) when daily minimums were below freezing and daily maximums were above freezing than during all other weather conditions (ANOVA $p=0.28$). It is hypothesized that these weather conditions allow for formation of a crust on the snow, enabling much easier travel. In addition, these weather conditions also increase odor from bait. Total captures also reflect this pattern (Figure 3). Many other species were captured in wolverine traps (Table 13). Log cabin traps were more successful in capturing wolverine than barrel traps (Table 12), although the latter offer the advantage of portability.

Table 10. Summary table of animal and monitoring history.

WOLVERINE NUMBER	NAME	SEX	AGE CLASS AT FIRST CAPTURE	ACTUAL AGE AT FIRST CAPTURE	NUMBER OF CAPTURES	DATES MONITORED
W01	Nina	F	yearling	Unknown	3	18/02/96→05/12/96 02/02/97→09/05/97
W02	Naomi	F	adult	4	4	20/02/96→11/06/96 16/02/98→15/12/98
W03	Wayne	M	juvenile	<1	10	20/02/96→12/06/96 24/02/97→08/07/97 16/03/98→present
W04	Houdini	M	adult	5	4	08/03/96→21/03/96 23/03/97 17/03/98→25/03/96
W05	Arnie	M	adult	Unknown	1	12/03/96→29/08/96
W06	Alison	F	juvenile	Unknown	1	21/03/96→24/07/96 23/03/97
W07	Diana	F	adult	3	4	23/03/96→21/08/96 06/03/97→24/09/97 06/03/98→present
W08	Halley	F	adult	Unknown	1	25/03/96→12/06/96
W09	Marley	F	juvenile	Unknown	3	11/04/96→11/10/96 01/03/97→08/07/97 26/11/97→09/12/97
W10	Cara	F	adult	Unknown	2	12/04/96→11/06/96 30/03/97→10/06/98
W11	Stella	F	adult	2	2	12/04/96→21/08/96
W12	Moose	M	adult	Unknown	1	14/01/97→07/03/97 18/03/98→26/08/98
W13	Maxine	F	adult	Unknown	2	31/01/97→26/06/97 18/03/98→26/08/98
W14	Magnus	M	juvenile	<1	1	06/02/97→09/07/97
W15	BibBob	M	adult	10	3	21/02/97→15/06/97
W16	Abigail	F	juvenile	<1	2	22/02/97→21/11/97
W17	Jacques	M	yearling	Unknown	3	24/02/97→01/08/98
W18	Luba	F	adult	6	3	02/26/97→03/09/97
W19	Kahn	M	yearling	1	2	26/02/97→05/06/97 03/03/99→present
W20	Borris	M	adult	5	2	27/02/97→28/05/97
W21	LeahRuth	F	juvenile	Unknown	2	27/02/97→14/07/97
W22	Jessica	F	juvenile	<1	1	22/03/97→08/08/97
W23	Mars	M	adult	Unknown	1	01/04/97→16/09/98
W24	Helene	F	adult	Unknown	1	13/04/97→11/02/98
W25	Davis	M	adult	Unknown	1	30/10/97→16/09/98
W26	Thor	M	adult	1-2	2	07/11/97→present
W27	Quill	M	yearling	Unknown	1	20/11/97→18/12/98
W28	Lola	F	yearling	Unknown	3	21/01/98→22/04/98
W29	Merlin	M	adult	Unknown	2	28/02/99→present
W30	Aurora	F	yearling	Unknown	1	13/11/98→present
W31	Luna	F	yearling	1-2	4	05/03/99→present
W32	Orion	M	yearling	1	1	06/03/99→present
W33	Aries	M	yearling	1	1	20/03/99→present

W34	Double Trouble	F	adult	6	4	01/03/99→26/08/98
W35	Payback	M	adult	5	3	01/03/98→15/12/98

Table 11. Capture session dates.

Session	**Dates**
Winter 1996	Jan 16/96 - Apr 17/96
Fall 1996	Nov 17/96 - Dec 12/96
Winter 1997	Jan 8/97 - Apr 15/97
Fall 1997	Oct 29/97 - Nov 30/97
Winter 1998	Jan 14/98 - Mar 25/98
Fall 1998	Nov 5/98 - Nov 25/98
Winter 1999	Feb 24/99 - Mar 25/99

Table 12. Wolverine live-capture success as a function of weather and trap type(captures/100 trapnights).

Session	Overall	Wx #1	Wx #2	Wx #3	Wx #4	Log Cabin Traps	Barrel Traps
Fall 1996	0		***0***			0	0
Fall 1997	0.46		0.55	0.34		.48	0
Fall 1998	0.45		0.48	0		.46	0
Winter 1996	1.41	0	1.08	1.82	1.46	1.81	0.31
Winter 1997	2.06	***0***	1.55	2.62	***0***	2.21	1.25
Winter 1998	2.43		2.04	3.02		2.43	
Winter 1999	3.69		2.72	4.33		3.69	
Mean	1.5	0	1.4	2.44	1.46	1.58	0.31

Wx #1 - minimum and maximum daily temperatures are below -25 ^{0}C
Wx #2 - minimum and maximum daily temperatures are between -25 ^{0}C and 0 ^{0}C
Wx #3 - daily minimum temperatures are below 0 ^{0}C and daily maximum temperatures are above 0 ^{0}C
Wx #4 - daily minimum temperatures are above 0 ^{0}C

Note: Numbers in ***bold italics*** are for trapping sessions which, based on the average number of trapdays/capture for that session, had too few trapdays to be likely to capture a wolverine. Mean capture rates are based only upon the numbers not in bold type.

Figure 3. Wolverine total captures by temperature regime.

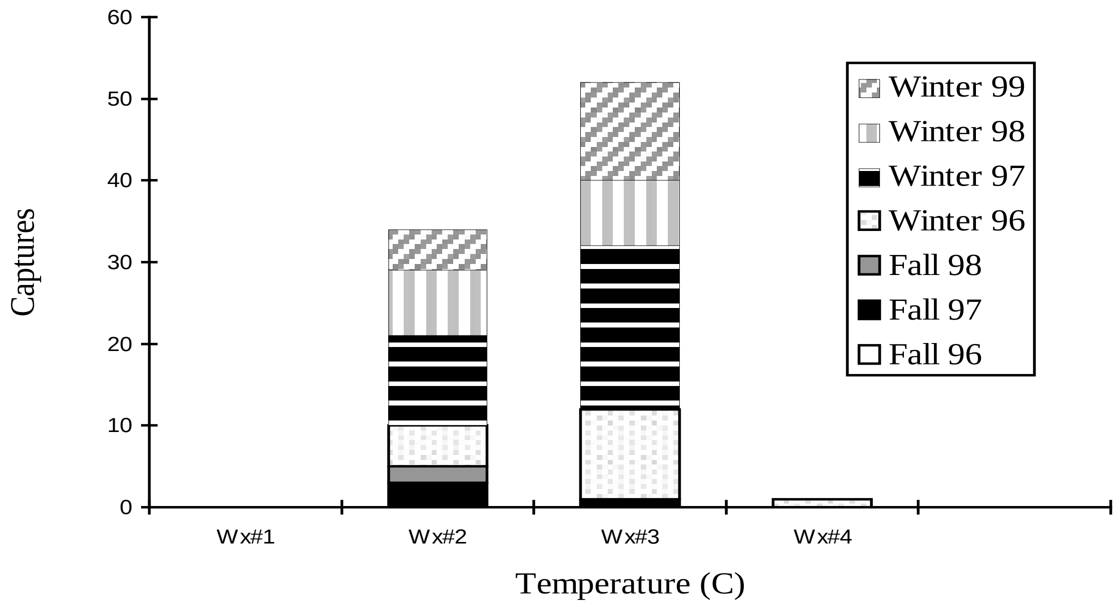


Table 13. Live capture summary by trapping session

		Live Captures								
Trap Session	Total Trapnights	Wolverine	Fisher	Marten	Mink	Ermine	Wolves	Foxes	Bears	Lynx
Fall 96	375.5	0	3	4	0	0	0	1	0	0
Fall 97	864	4	1	40	0	0	0	0	0	0
Fall 98	444.5	2	10	17	1	0	0	5	1	0
Winter 96	1202	17	6	24	0	0	1	1	0	0
Winter 97	1505.5	31	12	58	1	1	0	3	0	0
Winter 98	657.5	16	8	23	0	0	0	0	0	0
Winter 99	461	17	2	36	0	0	0	1	0	1

4.1.2 Morphometrics

The average weight of captured wolverines was 10.7 kg (+/-2.6, n=51) with a maximum reported weight of 16.3 kg (W15) and a minimum of 7.1 kg (W09). Average overall body length was 81.4 cm (+/-10.2, n=48), with a maximum of 109.0 cm (W35) and a minimum of 58.5 cm (W18). The averages for head and neck girths were 30.6 (+/-7.0, n=13) and 29.6 (+/-6.4, n=44) respectively. Weights, nose to tail body lengths, head and neck girth data are presented for each age and sex class in Table 14.

There was a pronounced sexual dimorphism between male and female wolverine. Hash (1987), also reports sexual dimorphisms. Males are 30 percent heavier and 10 percent longer than females. Banci (1994) reports a similar dimorphism of 30-40 percent in weight and 8-10 percent in length. Dimorphisms in this study are similar, with a 34.1 percent difference in adult weights and a 11.4 percent difference in lengths

Wolverine in this study area may be smaller than wolverine from other areas. Although observed weights are within reported ranges for wolverine, they are at the lower end of the range. Hash (1987) reported weight ranges for males of between 14 and 27.5 kg, and for females of between 7 to 14 kg. Wolverine in this study were 10.3 to 16.3kg for males and 7.5 to 11.0kg for females. Adult body lengths are within reported measurements of 65 to 105 cm (Hash 1987). Hash, however, does not report body length differences between males and females. Adult wolverine in this study are between 58.5 cm and 109 cm long, straddling Hash's (1987) overall range. Female weights fall well within reported ranges, however males within this study area are generally smaller than those elsewhere.

Wolverine likely have seasonal and annual weight changes. These changes may relate to differences in food availability and type between seasons and years. Some wolverine show changes in capture weights between years. For example, the weight of W03 ranged from 10.5 kg in 1996 to 12.5 kg in 1997 with both measurements recorded in the same month, however, in 1998 his weight dropped to 11.3 kg. Females may also undergo these changes. W02 varied from 8.9 to 10.4 kg showing a drop in weight between 1996 and 1998, and W07 varied only from 8.5 kg to 9.5 kg in four captures between 1996 and 1998.

Typical sexual dimorphism is present in head circumferences and neck girths with males head circumference being 19 percent larger than females (Table 14). Male neck girths were also 21 percent larger than females. However, the most notable feature of this analysis is a comparison between the two measures. In adult animals, a difference of only 0.4 cm was observed between head and neck girths. It is therefore understandable why collars fitted on animals with such a small neck to head ratio would not remain on the animal throughout yearly weight changes.

Foot dimension data indicates little sexual dimorphism (Table 15). Overall mean foot dimensions for adult wolverine were 7.3 cm (+/-1.3, n=45) by 8.8 cm (+/-2.6, n=44) for the front feet and 7.2 cm (+/-1.2, n=19) by 14.0 cm (+/-4.7, n=19) for rear feet. Current literature has suggested energy requirements for mustelids during winter travel is directly related to foot loading (Raine 1981). Since female wolverine have significantly smaller weights than males but similar foot sizes, it could be hypothesized that sinking depth during winter travel is reduced for females. Reduced sinking depths may mean lower energy requirements for travel and, an increased ability to travel in adverse snow conditions and proportionately more energy to put into reproduction. Male and female wolverine have different elevational habitat use patterns (see landscape scale habitat use section 4.3.2). These differences may be facilitated by reduced foot loading in females, easing travel in difficult snow conditions.

Despite these observations, a continual problem has been the collection of consistent foot dimension measurements. A standardized measure, possibly even an impression, is needed to accurately document foot dimensions. Changes in snow conditions also make it difficult to assess both track dimensions and sinking depth. Again, a standard measurement of track dimensions similar to that of the foot dimension measurements is needed, along with a standard measure of snow conditions.

Table 14. Summary of physical characteristics of captured wolverine (mean +/-std. dev. (sample size in parentheses)).

	Sex	Yearling	Juvenile	Adult
Weight (kg)	Male	12.2+/-1.4(7)	13.3+/-3.9(2)	13.5+/-1.5(14)
	Female	8.3+/-1.0(6)	8.4+/-0.6(6)	8.9+/-0.9(16)
Body Length (cm)	Male	81.4+/-11.7(7)	87.8+/-7.4(2)	88.7+/-9.6(13)
	Female	73.9+/-3.9(6)	77.1+/-9.6(6)	78.7+/-9.1(14)
Head Girth (cm)	Male	N/A	32.3 (1)	36.0+/-1.4(2)
	Female	31.0 (1)	29.4+/-1.2(2)	29.1+/-9.2(7)
Neck Girth (cm)	Male	32.0+/-2.4(5)	34.0+/-5.0(2)	33.9+/-1.9(13)
	Female	28.7+/-0.5(6)	24.1+/-10.7(6)	26.3+/-6.4(12)

Most females were caught in the first two years of the study. These were the only sessions where reproductive females were observed (Table 16). In the first year of the study females comprised 73 percent of wolverine captured. This fell to 56 percent in year two and 50 and 14 percent in years three and four respectively. In the first two years of the study between 30.0 and 37.5 percent of the females captured were in a reproductive state.

Table 15. Summary of foot dimensions of captured wolverine (mean +/-std. dev. (sample size in parentheses)).

	Sex	Yearling	Juvenile	Adult
Front Width (cm)	Male	6.8+/-1.1(6)	9.3+/-1.8(2)	7.6+/-1.2(13)
	Female	6.7+/-1.1(6)	7.1+/-2.1(5)	7.3+/-1.2(13)
Front Length (cm)	Male	8.9+/-2.9(6)	11.0+/-5.0(2)	9.9+/-2.2(12)
	Female	7.5+/-1.9(6)	7.3+/-2.3(5)	8.5+/-2.7(13)
Rear Width (cm)	Male	6.3+/-1.2(3)	N/A	7.6+/-1.0(7)
	Female	6.7+/-0.1(4)	N/A	7.8+/-1.7(5)
Rear Length (cm)	Male	15.7+/-2.5(3)	N/A	14.6+/-5.3(7)
	Female	11.5+/-5.6(4)	N/A	13.3+/-4.7(5)

Table 16. Reproductive status of female wolverine at time of capture.

Year	Female percentage of captures	Non-reproductive females	Reproductive females
Spring 1996	73% (n=8)	62.5%	37.5%
Spring 1997	56% (n=9)	70.0%	30.0%
Spring 1998	50% (n=4)	100%	none
Spring 1999	14% (n=3)	100%	none

4.1.3 Immobilization Physiology

Fifty-two out of 53 immobilizations were begun with Telazol. Dosages were administered at 10 mg/kg of the estimated body weight. The average dose received by all animals was 14.0 mg/kg actual body weight (std. dev =8.0, n=53). Table 17 gives a breakdown of average doses of Telazol received by each age and sex class. This dose produced mean first effect times of 10.5 minutes and mean induction times of 12.4 minutes for all wolverine combined. Ranges for first effect and induction times are large. First effect times ranged from 1.0 to 39.0 minutes and induction times range from 2.0 to 73.0 minutes. Considerable variation exists within these times, as well as between age and sex classes, with no real trends apparent within these classes (Table 18). Both first effect and induction times are small for animals that receive the total estimated dose of Telazol for their weight. First effect times for a single administered dose are all under 4 minutes and induction times for a single administered dose are under 13 minutes. If the animal did not receive the entire dose during the initial attempt to administer the drug, both times increase with the number of successive attempts. Additional injections of Telazol after a significant amount of the drug has been metabolized, seemed to produce little or no increase in anesthetic effect.

Table 17. Summary of actual dose of Telazol received by animals (value +/-std. dev, (sample size in parentheses)).

	Sex	Yearling	Juvenile	Adult
Actual Dose Received (mg/kg)	Male	15.9+/-9.2(6)	11.8+/-3.5(2)	13.3+/-8.4(16)
	Female	16.5+/-7.4(6)	19.4+/-12.6(6)	12.8+/-4.1(16)

Table 18. Summary of first effect and induction times for handled wolverine (value +/- std. dev. (sample size in parentheses)).

	Sex	Yearling	Juvenile	Adult
First Effect Time (min)	Male	4.0 (1)	N/A	9.8+/-10.3(5)
	Female	5.0+/-1.4(2)	N/A	17.7+/-19.4(3)
Induction Time (min)	Male	25.3+/-12.6(5)	7.0+/-5.7(2)	17.5+/-20.4(12)
	Female	6.8+/-5.7(4)	13.7+/-12.4(6)	6.2+/-5.7(14)

Other drugs were also used during immobilizations. In three of these cases only partial doses of Telazol were given, due to problems with drug delivery. On two occasions ketamine was used to immobilize animals which either did not receive or did not respond to Telazol. W31 received three partial injections during a 20-minute (16.5 mg/kg total) period, and still maintained some activity. A knock down injection of ketamine (3.1 mg/kg) was used to complete the immobilization. In the second wolverine

(W32), a dose of 150 mg of Telazol (14.0 mg/kg) was administered in two injections over 14 minutes. This was insufficient to immobilize the animal. Two injections of ketamine (20.6 mg/kg) were used to complete the immobilization. On the third occasion, the wolverine (W19) was given six partial injections of Telazol (24.3 mg/kg). The excessively high dose can be attributed to Telazol crystallization, in either the syringe or the vial, hampering administration and/or metabolism of the drug. Following the injections, the animal was allowed to recover and injections of ketamine/metatomadine (4.3/4.3 mg/kg), Telazol/metatomadine (3.6/2.9 mg/kg), and finally two injections of ketamine/xylazine (25.7 mg/kg total) were given to subdue the animal. In two other immobilizations, ketamine was used as a top-up drug to maintain sedation during handling. As expected, ketamine top-ups did not increase or deepen immobilization but did delay recovery slightly.

In a single case (W03), a ketamine/metatomadine (13.1/11.7 mg/kg) combination was used as the initial immobilization drug. Subsequently, atropine sulfate (0.2 mg/kg) was administered 20 minutes into the immobilization to speed a slow heart rate. The immobilization was ended after approximately 50 minutes with two injections of the antagonist atipamazol (0.3 mg/kg total).

The anesthetic effects of Telazol have proven effective for handling, and in minor surgical procedures such as ear tagging and tooth removal. If these procedures are performed during the deepest stages of immobilization (i.e. approx. 15 min from the initial injection in ideal situations), little response is noticed in the animal. However, as the anesthetic effect weakens stimuli from painful procedures seem to speed recovery time. This, in effect, stimulates the animal out of the anesthetic.

The use of isoflourine gas in radio implant surgeries has proven highly effective. The rapid responses of an inhaled gas, and the ease with which the sedation can be controlled are the main benefits of gaseous anesthetic. However, the equipment needed to administer a gaseous anesthetic may not always be transportable to the capture locations. The single situation in which this occurred, a single dose of Telazol/metatomadine and one of ketamine/metatomadine were used to immobilize the wolverine. There is some concern, especially in ruminants, that metatomadine may have detrimental effects on late term pregnancies (M. McAdie, pers., comm.). Although this immobilization was performed on a female wolverine, it occurred in a fall trapping session allowing the use of metatomadine. However, care should be taken when using metatomadine on female animals during spring trapping sessions.

There is a large difference between the estimated amount Telazol given and the actual amount needed to immobilize animals. These differences can be attributed to the increased number of doses required to immobilize animals with multiple injections. It appears that the longer the elapsed time between the initial and final injections, the less effective Telazol becomes. Therefore, until the initial dose has been completely metabolized additional doses of Telazol may have reduced effects. These results are consistent with the recommendation for the use of ketamine to "maintain Telazol initiated anesthesia" (Woodbury 1996).

Some irregularities existed in the administration dose of Telazol. Ambient and drug temperatures, as well as animal stress and condition both seem to influence first effect and induction times. But perhaps the largest effect comes from problems during drug delivery arising from both these factors. At significantly cold ambient temperatures, those at or below -20^{0}C, Telazol can gel or freeze in needle tips, hampering delivery of the drug. Delivery was also hampered by a number of animal behaviors. Animals may bite at needles, sometimes removing syringes. Some drug may be administered orally during this process. Another behavior is a quick or sharp turn or twist at the moment the needle touches the animal. This behavior bends the needle as the animal pulls away, cutting short the administration of the drug. However, proper care when administering drug, and the use of propylene glycol when mixing drugs at cold ambient temperatures, can greatly ease the drug delivery process.

Mean respiration rates for immobilized wolverine were 22.1 breaths per minute (Bpm), with mean values ranging from 10.0 to 60.0 Bpm (Table 19). During immobilizations where successive measurements were taken, respiration rates were stable throughout the immobilization. A single wolverine had an elevated respiration rate during the first measurement. This activity subsided as the immobilization progressed, and is most likely attributed to handling stress (M. McAdie, pers. comm.). Mean wolverine heart rates were 137.0 beats per minute (bpm) and ranged from 90.0 to 200.0 bpm. Again, values were stable throughout immobilizations. A qualitative measure of capillary refill time (crt) was also taken. These results were good, with times generally below the 1 to 2 second time periods

Rectal temperatures varied from 32.7 ^{o}C to 39.0 ^{o}C (Table 19). The mean rectal temperature was calculated to be 36.9 ^{o}C (+/-1.6, n=12). A series of rectal temperatures were taken at only a single immobilization, during which time the wolverine's body temperature dropped from 37.6 ^{o}C to 35.8 ^{o}C. This change occurred over a period of approximately one hour, and at an ambient temperature of approximately 10 ^{o}C. Although drops in body temperature during handling have not been perceived to be a problem with wolverine, it is considered a significant factor during fisher immobilizations. Therefore, body temperature should be monitored during Telazol immobilizations at cold ambient temperatures, or when wolverine are wet.

Table 19. Physiological parameters of wolverine during immobilization (value +/-std. dev. (sample size in parentheses)).

	Sex	Yearling	Juvenile	Adult
Mean Respiration Rate (Bpm)	Male	16.25+/-5.7(4)	N/A	14.8+/-4.9(7)
	Female	24.0+/-5.7(2)	40.0 (1)	32.8+/-16.3(7)
Mean Heart Rate (bpm)	Male	150.0+/-8.5(2)	N/A	148.3+/-44.3(6)
	Female	116.8+/-12.5(2)	105.0 (1)	129.9+/-22.4(3)

Mean Rectal Temperature (Celsius)	Male	37.5 (1)	N/A	35.8+/-2.3(4)
	Female	37.3+/-1.0(2)	38.0 (1)	37.4+/-1.4(4)

4.1 Movement and Home Range

Wolverines were monitored using both aerial and ground telemetry. Some single locations were also obtained with remote cameras set up for the development of inventory methodologies. Relocation frequencies varied from a minimum of 4 (W18) locations per wolverine to a maximum of 122 (W07). Home ranges varied in size from as low as 158 km^2 (W28 - female with location data over a limited time period) to as high as 7622 km^2 (W03 - dispersing juvenile male) (Tables 20,21). Home range estimates are incomplete for some wolverine, as the majority of sampling has occurred in seasons 1 and 2 due to early collar loss in many animals (Figure 4). Home ranges of most adult females are relatively small, and all enclose a significant portion of high elevation habitat (Figures 5). Adult male home ranges are more than twice as large (Figure 6). Subadult home ranges tend to be larger than those of adults, and may often be a series of disjunct polygons as these animals spend periods of time in one area, then undertake long movements to a new area before presumably setting up their adult home range. Wolverine W03 is the best example in the data set, with a subadult home range more than ten times the size of his adult home range (Figures 7,8). Movements vary from very little (2-5 kilometers) on a daily or weekly basis to very large (more than 100 km). Three wolverines exhibited very long movements. Wolverine W14 crossed Williston Reservoir twice in the three months he was monitored. His final location was 107 km from his initial capture location. Wolverines W23 and W34 both had one time long distance movements of greater than 100 km. Three wolverine (all male - W14, W23, W25) crossed Williston Reservoir on multiple occasions.

Table 20. Home range size for adult radio-transmittered wolverines (using Adaptive Kernel methods). Numbers in brackets after home range size are number of locations. All home range sizes do not include areas of open water.

Female Wolverine		Male Wolverine	
Wolverine	Home Range Size	Wolverine	Home Range Size
W02	325.4 (57)	W03 (52)	579.7
W07	409.8 (122)	W04 (24)	450.8
W08	553.3[1] (6)	W05 (13)	487.5[1]
W10	322.7 (72)	W12 (8)	517.6[1]
W11	351.5[1] (12)	W15 (23)	1416.6
W13	574.8 (48)	W19 (8)	856.2[1]
W18	n/a (4)	W20 (16)	1592.6[1]
W21	233.4 (25)	W23 (65)	4431.6[2]
W34	1842[3] (18)	W25 (41)	3096.2[2]
		W26 (68)	2288
		W29 (10)	403[1]
		W35 (30)	4953.2
Mean	512.5		1756.1

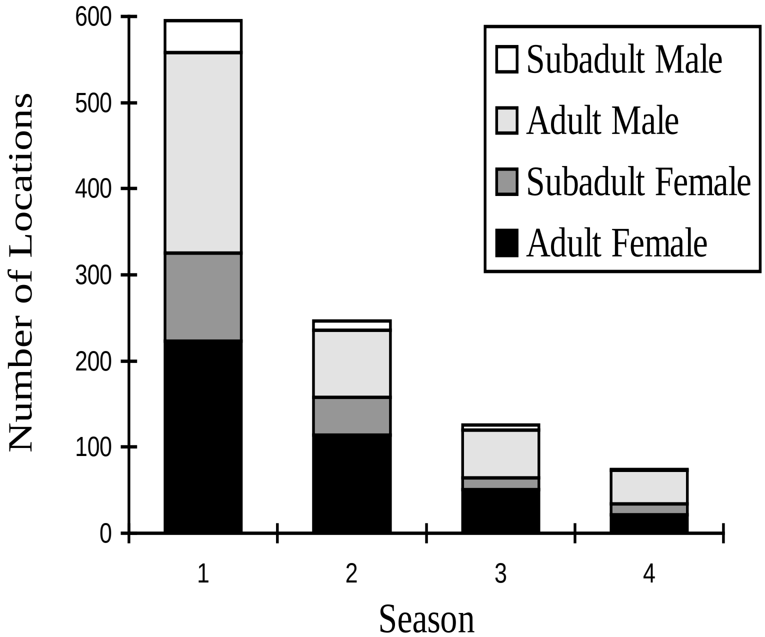
1 - too few locations to describe home range accurately
2 - home range is on both sides of Williston Reservoir
3 - involves a large dispersal movement to the Middle River.

Table 21. Home range size for subadult radio-transmittered wolverines (using Adaptive Kernel methods). Numbers in brackets after home range size are number of locations. All home range sizes do not include of open water.

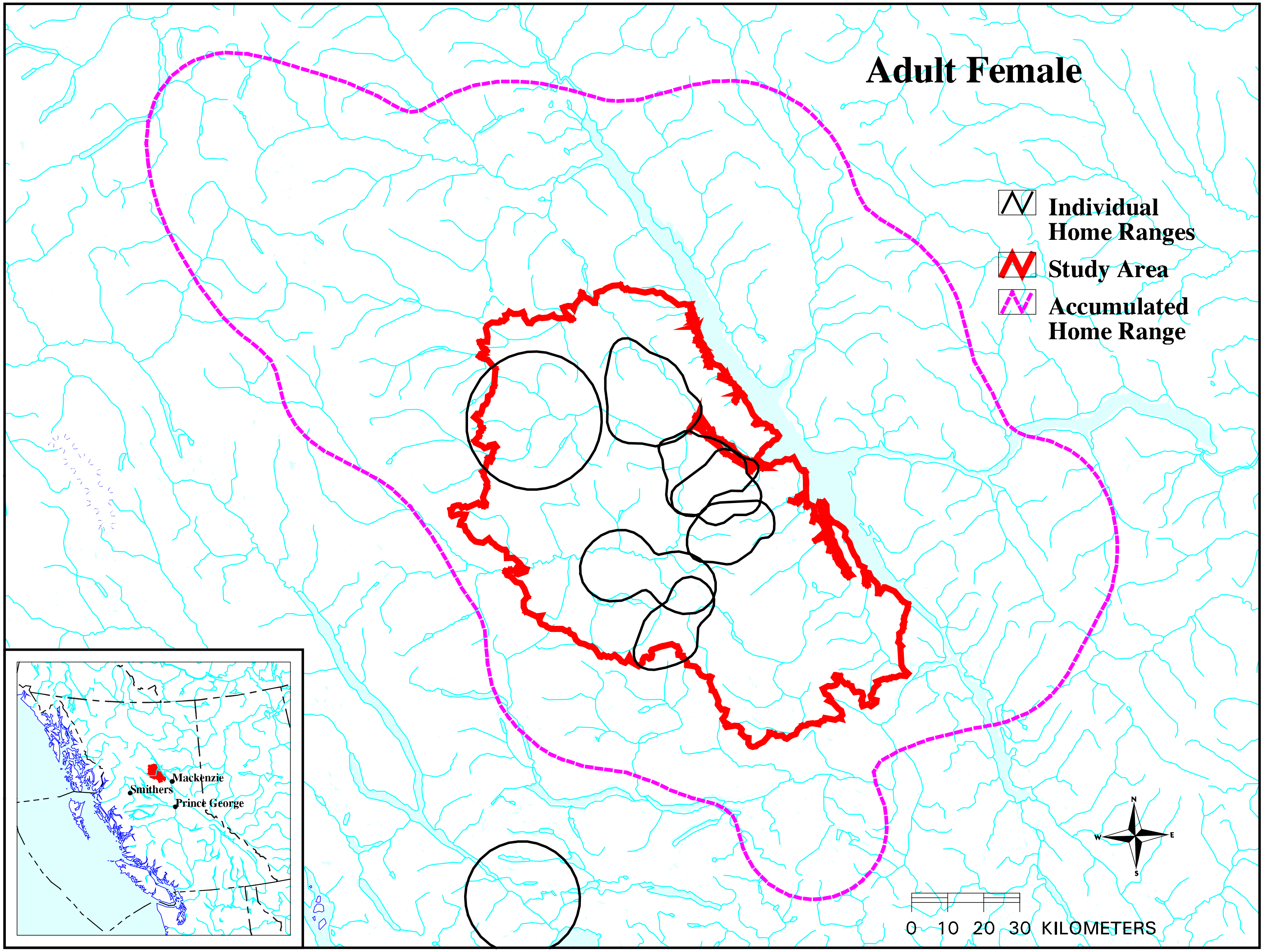
Female Wolverine		Male Wolverine	
Wolverine	Home Range Size	Wolverine	Home Range Size
W01	2492.4 (37)	W03	7351.6 (30)
W06	683.2[1] (10)	W14	4719.9[1] (16)
W09	578.6 (39)	W17	2452.2 (29)
W16	1147.6 (36)	W19	902.4[1] (17)
W22	1729.0 (25)	W27	333.4[1] (8)
W24	4852.8 (26)	W32	2952[1] (7)
W28	157.1[1] (19)	W33	n/a (2)
W30	856.2 (21)		
W31	1023.6[1] (9)		
Mean	1502.3		3118.6

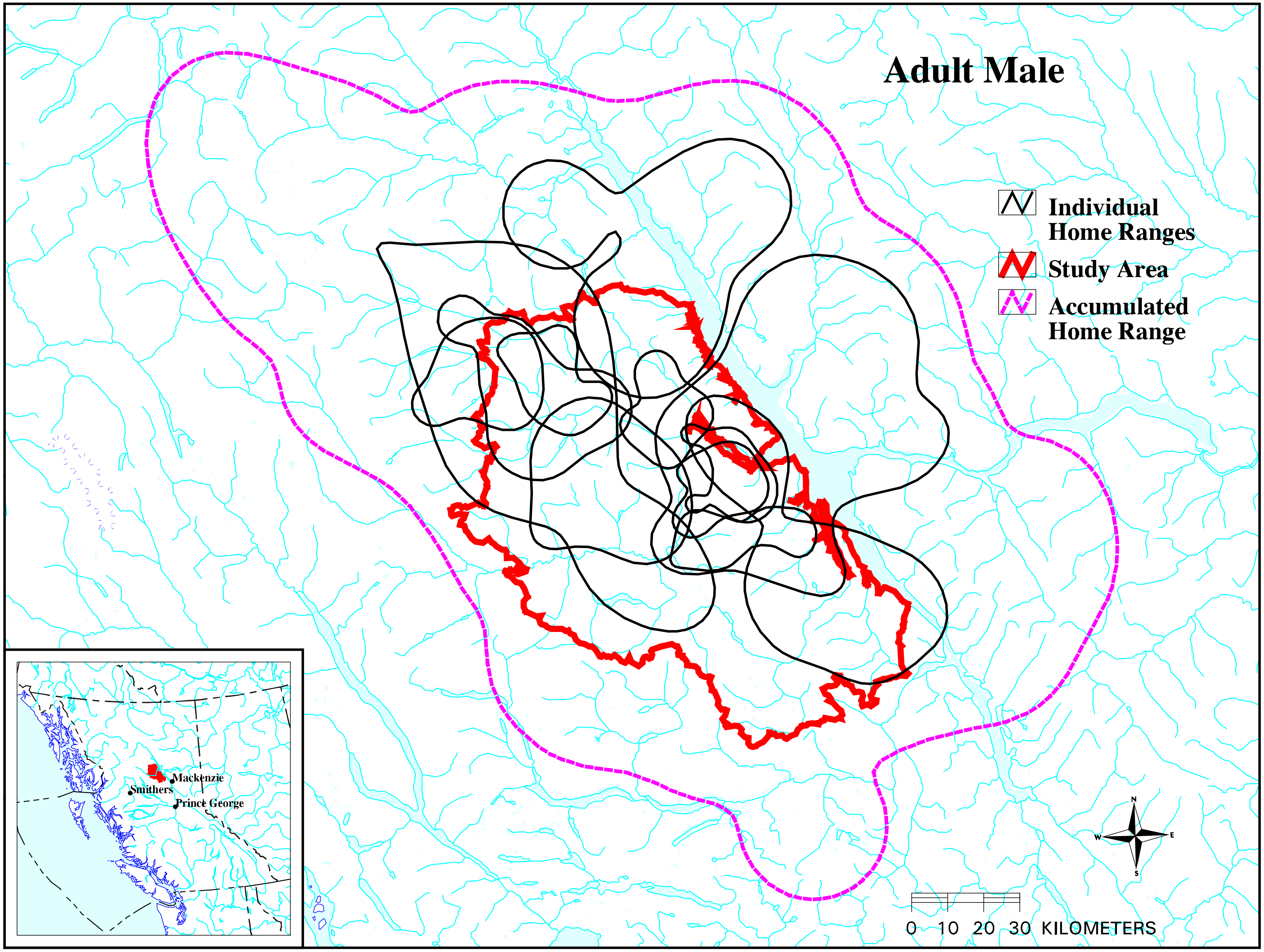
1 - too few locations to describe home range accurately
2 - home range is on both sides of Williston Reservoir

Figure 4. Number of wolverine locations by season.

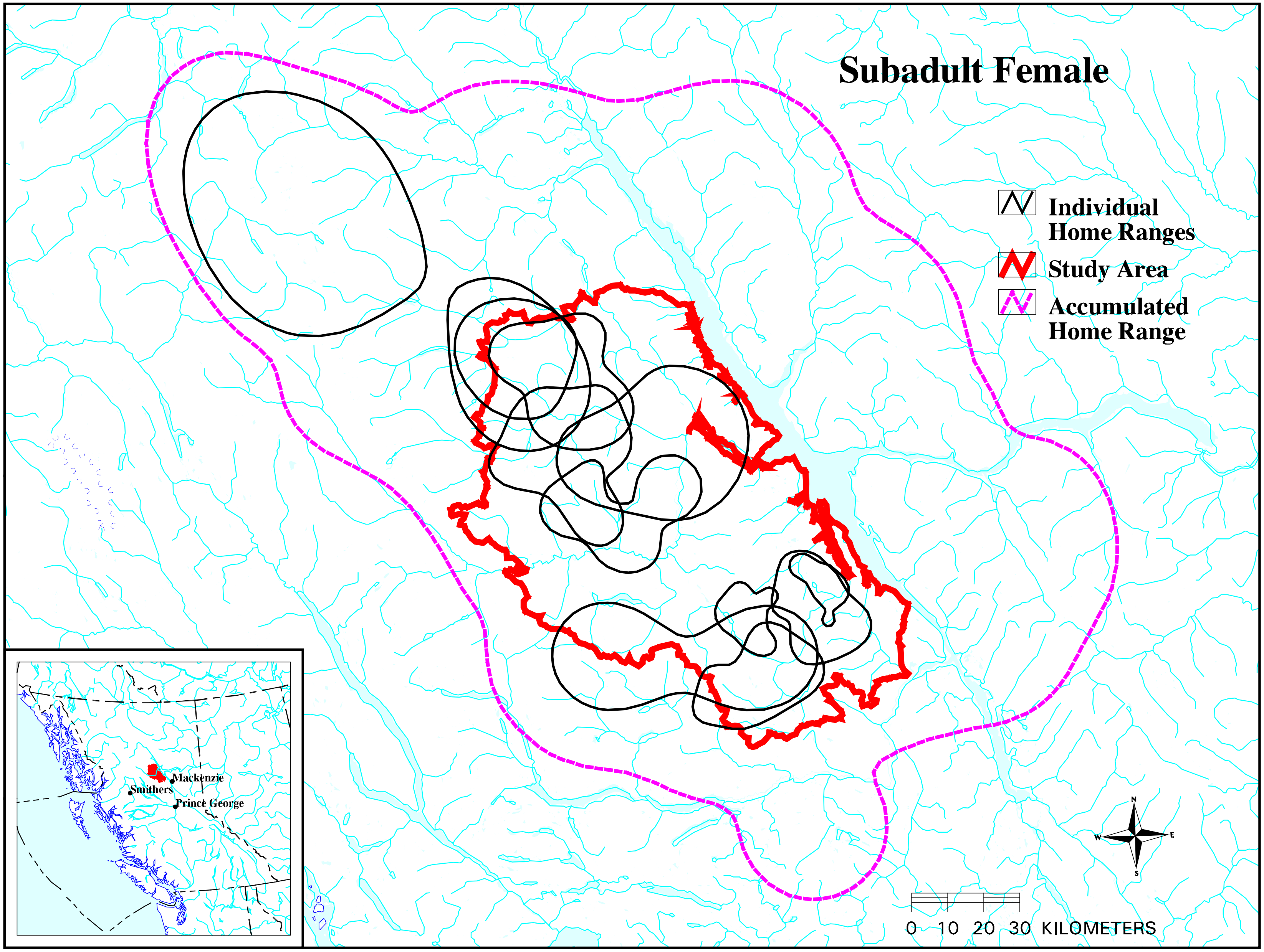


Figures 5-8. Home range boundaries for adult females, adult males, subadult females and subadult males respectively.

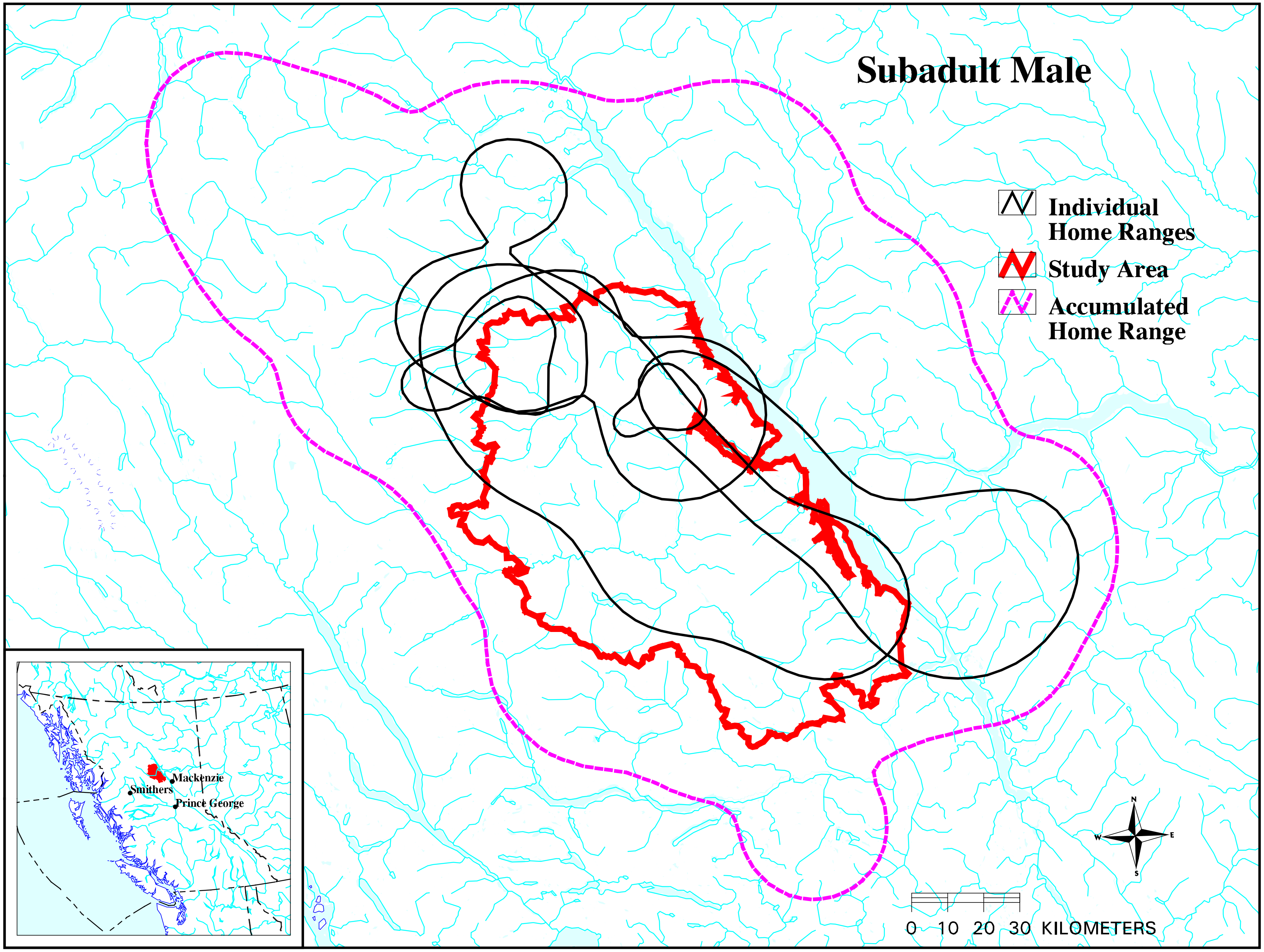

Adult Female
Individual
Home Ranges
Study Area
Accumulated
Home Range
Mackenzie
Smithers
Prince George
N
W
E
S
0 10 20 30 KILOMETERS



Adult Male
Individual
Home Ranges
Study Area
Accumulated
Home Range
Mackenzie
Smithers
Prince George
N
W
E
S
0 10 20 30 KILOMETERS



Subadult Female
Individual Home Ranges
Study Area
Accumulated Home Range
Mackenzie
Smithers
Prince George
0 10 20 30 KILOMETERS


Subadult Male
Individual Home Ranges
Study Area
Accumulated Home Range
Mackenzie
Smithers
Prince George
N
E
S
W
0 10 20 30 KILOMETERS

4.3 Habitat Use

4.3.1 Wolverine Seasons

Four seasons of activity were identified for wolverines in the study area. Seasons of activity are periods of the year during which behaviour and habitat use may be consistent and influenced by biological imperatives (e.g. breeding) and weather phenomena (Table 22). Start and end dates for seasons vary from 1 to 33 days among years, depending on major changes in temperature and snow depth. The greatest variation in start and end dates among years is between season 3 and season 4 which is when snow becomes deep enough that travel likely becomes difficult.

Table 22. Season dates by year for the Northern Wolverine Project, 1996-1999.

	Season			
Year	1	2	3	4
1996	Feb 18 - May 25	May 26 - Aug 31	Sept 1 - Nov 16	Nov 17 - Feb 15/97
1997	Feb 16 - May 29	May 30 - Aug 30	Aug 31 - Dec 6	Dec 7 - Feb 14/98
1998	Feb 15 - May 30	May 31 - Aug 29	Aug 30 - Dec 18	Dec 19 - Feb 23/99
1999	Feb 24 - May 28	May 29 – Aug 28	Aug 29 – Dec 11	Dec 12 – Feb 22/00

Season 1: during this period female wolverine are whelping kits and involved in nursing and weaning; snow conditions during this time vary from crusted snow as a result of daily melts and overnight freezing temperatures to valley bottoms barren of snow in the latter part of the season.

Season 2: during this period female wolverine are provisioning young; this is the mating season for wolverine.

Season 3: during this period kits are dispersing and snow begins to appear in the high elevation habitats.

Season 4: this period is one of cold temperatures (as a rule) and large snowfalls resulting in deep, soft snow which potentially impedes movement.

4.3.2 Landscape Scale

There was no significant selection patterns of habitat included in home range relative to that available within the study area (Table 23).

Table 23. Landscape scale (within study area) selection for home ranges within zones by transmittered wolverine. Numbers represent the number of animals demonstrating significant selection ($p < 0.05$) or avoidance of inclusion of habitat in within their home range in proportion to availability within the study area.

	AT	BWBS	ESSF	SBS
Adult Female				
Avoid	1	1		
Neutral	4	3	2	5
Select		1	3	
Subadult Female				
Avoid	2	2		3
Neutral	7	7	8	3
Select	3	3	4	6
Adult Male				
Avoid	2	2	2	1
Neutral	5	3	5	2
Select	2	4	2	6
Subadult Male				
Avoid		1		1
Neutral	7	4	7	4
Select		2		2

Mean monthly elevations of wolverine ranged from a low of 700m to a high of 1587m (Figure 9) . Lowest elevations were recorded in the cold and snowy months of season 4. Highest elevations were recorded during season 2. Adult female locations were at significantly higher elevations than all other sex and age classes in season 1 (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). There were no significant differences between the other sex and age classes in this season. Adult females make the most use of high elevation habitats during this season for maternal den sites. In season 2, the mean elevations of adult and subadult female locations were not significantly different, but both were significantly higher than those of adult males which were significantly higher than those of subadult males (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). During season 3, mean adult female locations were significantly higher than those of adult males and subadult females (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). Adult males were significantly higher than subadult males. There was no significant difference between the elevation of subadult males and females. In season 4, adult female locations were higher than subadult males (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). There were no differences between any other classes. Mean elevations of adult females varied across seasons. Season 2 and 3 locations were higher than seasons 1 and 4 (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). Seasons 2 and 3 are when adult females are with kits. Subadult females are higher in season 2 (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$) than during all other seasons. There were no differences in location elevation among the rest of the seasons.

Adult male locations were higher in season 2 during the breeding season than in season 3 (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). Adult male locations in seasons 1 and 4 were lower than the former two seasons (ANOVA $p<0.001$; Duncan Multiple Range Test $p < 0.05$). Subadult male locations were always lower than the other sex and age classes, and did not vary significantly over seasons (ANOVA $p=0.2260$). Mean caribou and wolf location elevations over these seasonal definitions are detailed in Figure 9 as well. Mean elevation of caribou elevations were consistently high and overlapped those of the adult female wolverine. Mean elevation of wolf locations were consistently low and overlapped those of the subadult males in season 2 and all but adult female wolverine in all other seasons.

Figure 9. Mean elevations of radio-collared wolverine by season.

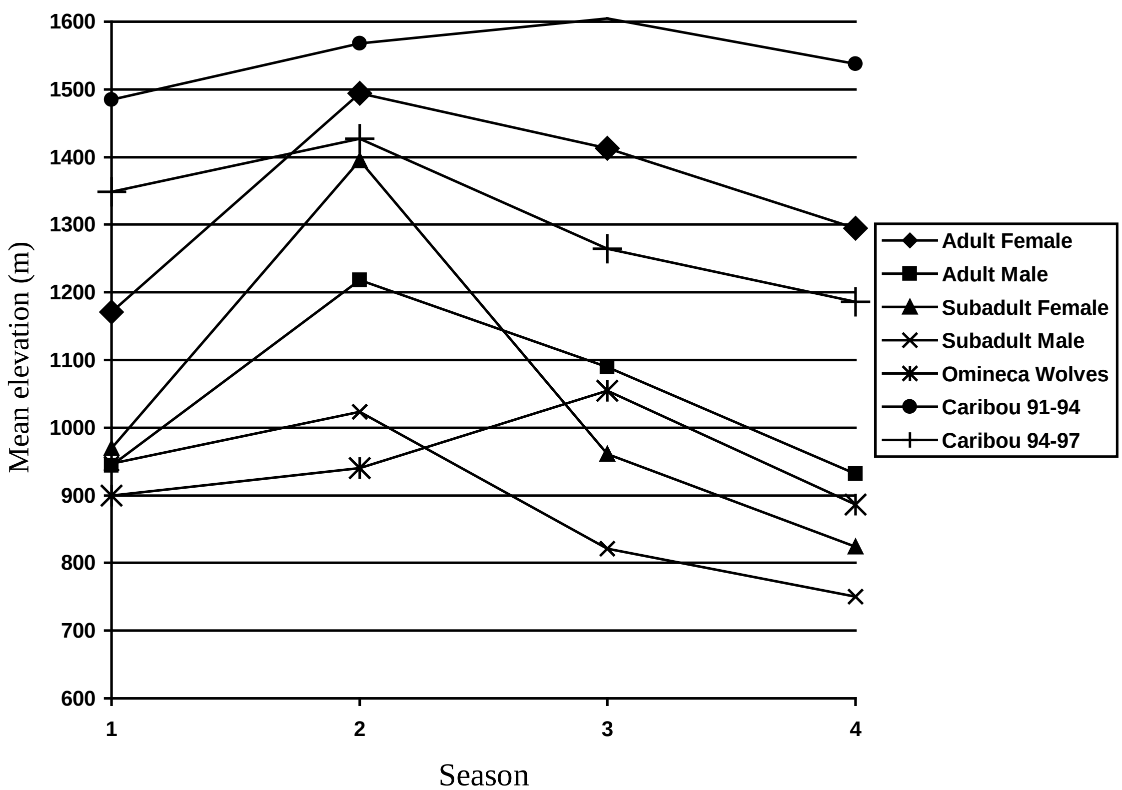


Figure 10. Elevational distribution of locations for adult female wolverine.

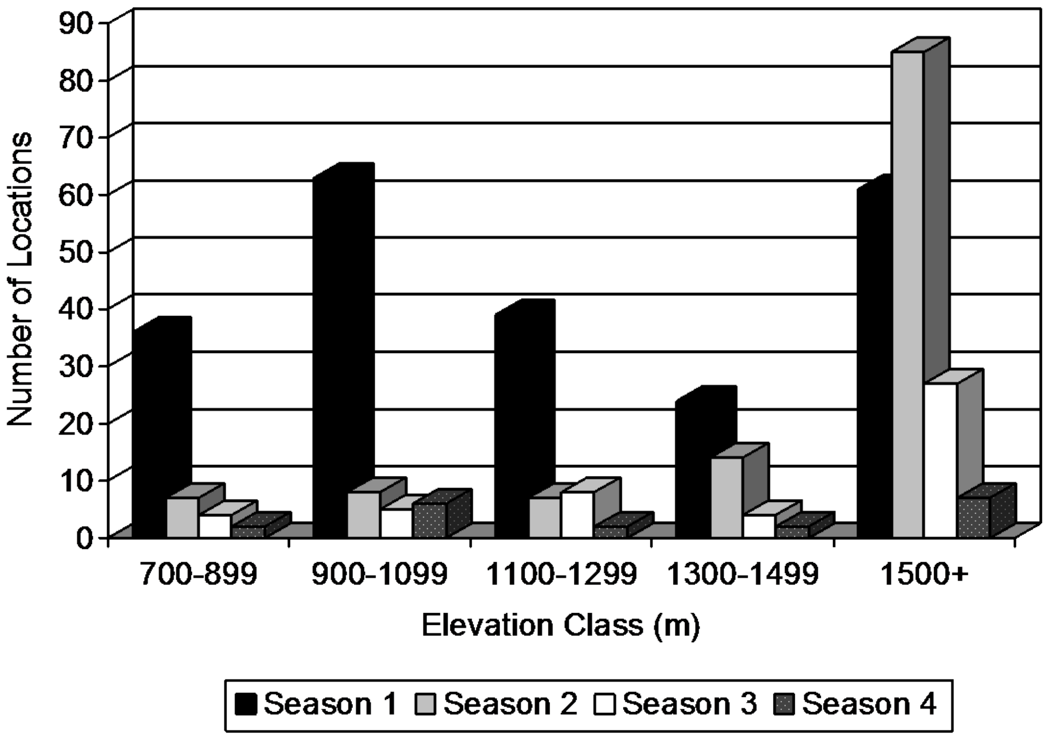


Figure 11. Elevational distribution of locations for subadult female wolverine.

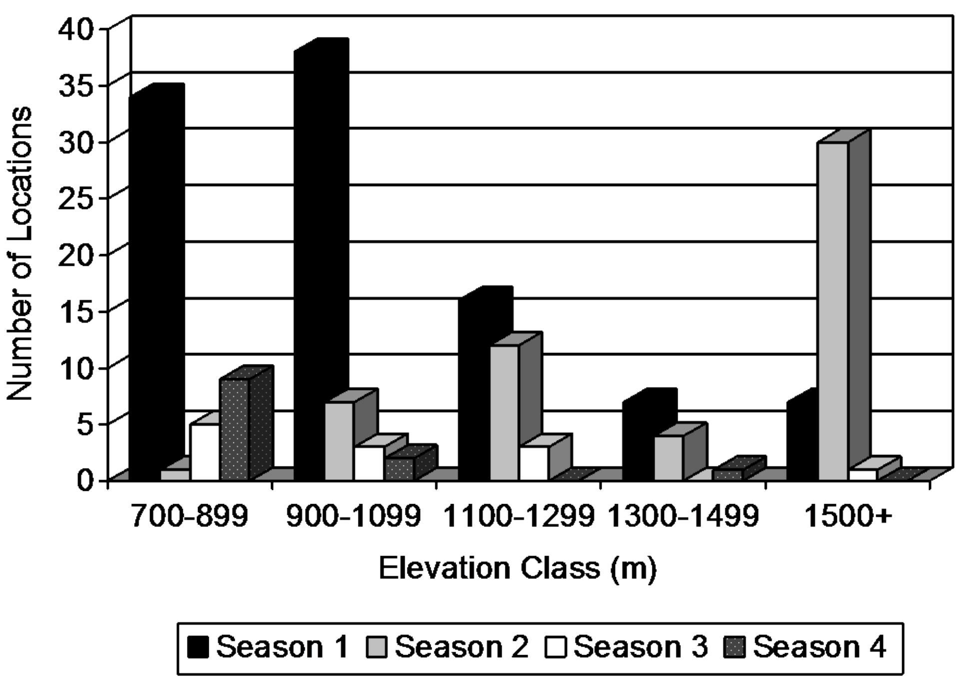


Figure 12. Elevational distribution of locations for adult male wolverine.

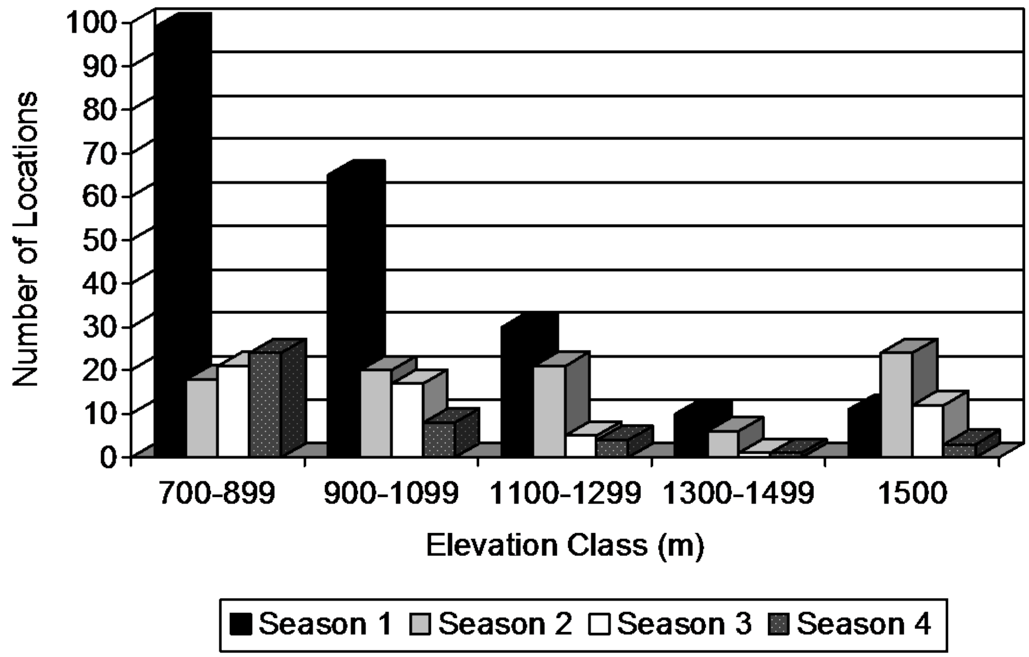
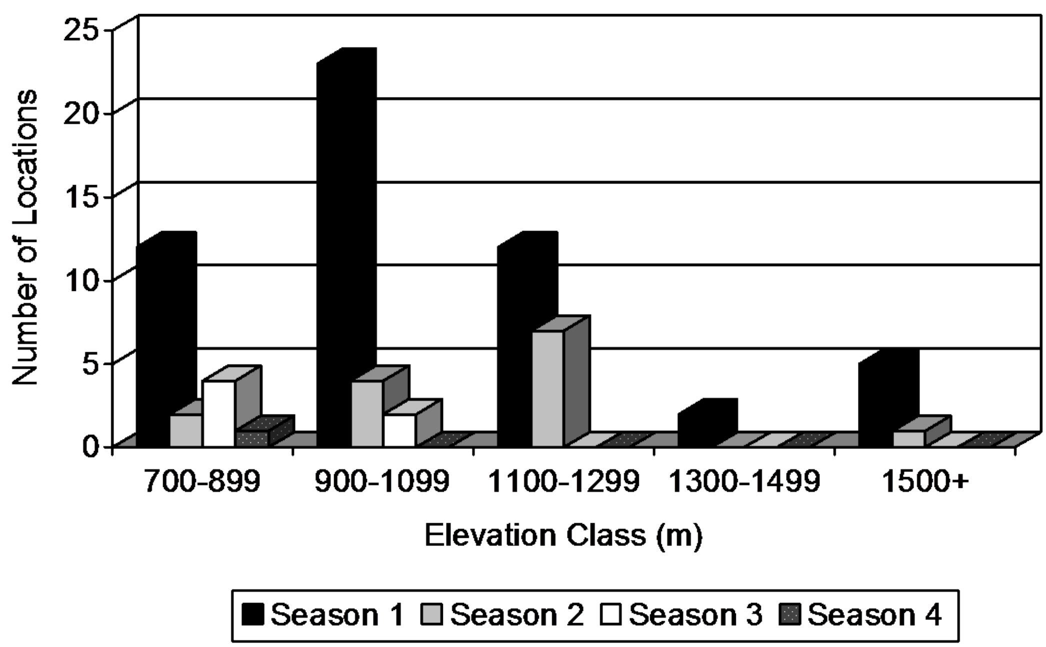


Figure 13. Elevational distribution of locations for subadult male wolverine.



Adult females were located more frequently than other sex and age classes in Alpine Tundra and Engelmann Spruce Subalpine Fir biogeoclimatic zones in almost all seasons (Tables 24-27). Subadult females were located with nearly the same frequency as adult females in these zones in season 2. In general males of both age classes made more use of Sub-Boreal Spruce and Boreal Black and White Spruce biogeoclimatic zones. Subadult females were located in these zones more frequently than adult females, however they made more use of the Engelmann Spruce Subalpine Fir zone than did males. These patterns are reflected in the mean elevation of locations (Figure 9). Adult female habitat use shows a nearly bimodal pattern in season 1, with most locations in ESSF and BWBS zones. During this period adult females may have maternal den sites at high elevation (all have been located in high elevation ESSF) while they are still foraging at low elevation. The majority of adult female locations in season 2 are in AT and ESSF habitats. At this time adult females are nursing kits and likely feeding on marmots and ground nesting birds. Although more use is made of lower elevation SBS and BWBS habitats in season 3, more than half of adult female locations are in AT and ESSF. While mean elevations are much higher than all other age and sex classes in season 4 (Figure 9), habitat use is more evenly distributed among zones than other seasons. Adult female home ranges, in general, tend to straddle high elevation habitat. Higher mean elevations during this season may be an artifact of the nature of their home ranges. Adult females have the smallest home ranges, and if during this season most foraging activity is at lower elevations, and the amount of lower elevation habitat is, they may need to travel back and forth over high elevations to visit low elevation foraging habitat. Other sex and age classes may have enough low elevation habitats in their home range, and their home ranges may be configured such that they are not forced into traversing ESSF and AT habitats. The elevational distribution of subadult female locations is essentially unimodal, with season 2 being the exception (Figure 11). This is reflected in the distribution of locations by biogeoclimatic zone (Table 25). Adult male wolverine are located most frequently in SBS and BWBS habitats and use AT and ESSF habitats most during mating season (season 2), where they have greater chances of encountering receptive females (Figure 12, Table 26). Subadult male locations are concentrated in the lower elevation SBS and BWBS habitats in all seasons (Figure 13, Table 27).

Table 24. Habitat use of biogeoclimatic zones by adult female radio-collared wolverine (percent of locations by season).

	Season				
Biogeoclimatic Zone	1	2	3	4	Overall
AT	6	36	27	19	18
ESSF	34	45	39	38	38
SBS	18	9	14	19	15
BWBS	42	10	18	24	29
SWB	0	0	2	0	<1

Table 25. Habitat use of biogeoclimatic zones by subadult female radio-collared wolverine (percent of locations by season).

	Season				
Biogeoclimatic Zone	1	2	3	4	Overall
AT	2	20	0	0	6
ESSF	23	57	31	15	31
SBS	58	20	46	31	45
BWBS	18	2	23	54	17
SWB	0	0	0	0	0

Table 26. Habitat use of biogeoclimatic zones by adult male radio-collared wolverine (percent of location by season).

	Season				
Biogeoclimatic Zone	1	2	3	4	Overall
AT	3	19	13	5	8
ESSF	9	32	16	10	15
SBS	38	33	46	69	41
BWBS	49	15	25	15	36
SWB	<1	0	0	0	<1

Table 27. Habitat use of biogeoclimatic zones by subadult male radio-collared wolverine (percent of locations by season).

	Season				
Biogeoclimatic Zone	1	2	3	4	Overall
AT	3	0	0	0	2
ESSF	14	30	0	0	15
SBS	24	0	83	0	26
BWBS	59	70	17	100	57
SWB	0	0	0	0	0

The use by wolverine of older forest habitats (see section 4.3.3) is further demonstrated at a landscape scale by an examination of the nature of live capture data, and may be influenced by the presence of human activity. Traps located in isolated patches of forested habitat surrounded by early successional habitats captured no wolverine (Figure 14, Table 28). Capture rates were similar for traps located in large tracts of contiguous forest and traps located in forested corridors in locations remote from human activity. Traps located in forested corridors adjacent to human activity had capture rates 3-4 times higher than the previous two types (ANOVA $p<0.0001$; Sheffe Multiple Comparison $p<0.05$). Our interpretation is that as proximity to human activity increased, the importance of forested cover (presumably as security cover) increases. We hypothesize that as forest harvesting creates a matrix of cut and uncut stands, wolverine are “funneled” into the uncut forested areas, and that as the proximity to human activity increases wolverine may be more sensitive to the need for forested habitat. As a result their chances of encountering a live trap are significantly increased.

Figure 14. Capture success of wolverine live traps by trap location.

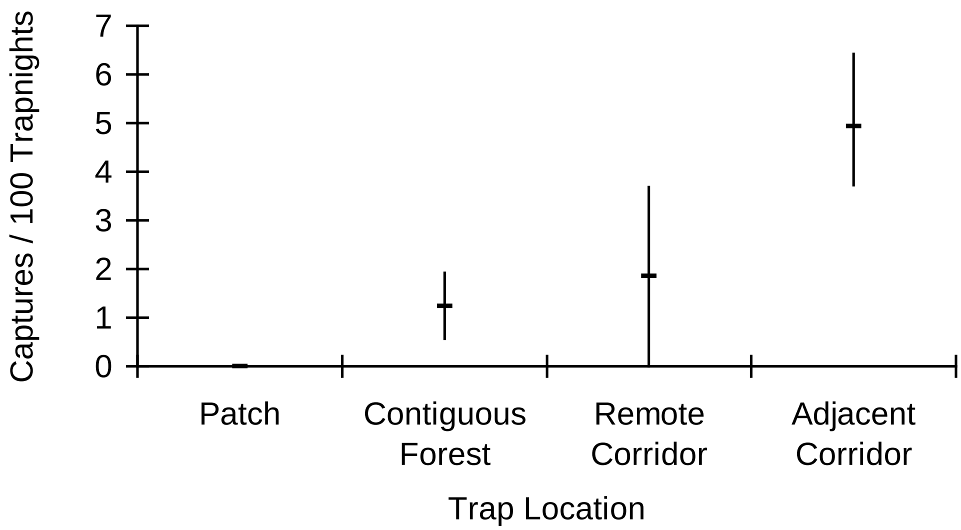


Table 28. Wolverine live-capture success as a function of trap location for all trap sessions (captures/100 trapnights).

Session	Patch	Contiguous Forest	Remote Corridor	Active Corridor
Fall 1996	***0***	***0***	***0***	***0***
Fall 1997	***0***	0.25	***3.41***	***0***
Fall 1998	***0***	0.74	***0***	***0***
Winter 1996	0	1.11	1.08	5.06
Winter 1997	0	1.5	2.61	4.03
Winter 1998	0	2.11	***0***	4.28
Winter 1999	0	1.74	***0***	6.98
Mean Captures	0	1.24	1.85	5.09
Mean Trapnights/Session	132.5	321.7	196.8	246.6

Note: Numbers in ***bold italics*** are for trapping sessions where, based on the average number of trapdays/capture for that session, had too few trapdays to be likely to capture a wolverine. Mean capture rates and trapnights/session are based only upon the numbers not in bold type.

4.3.3 Stand Scale

Stand scale selection of habitat within home ranges was evaluated for 7 adult females, 7 subadult females, 10 adult males and 5 subadult males (Tables 29-32). An additional 7 wolverine were omitted from due to inadequate sample sizes for these analyses. One wolverine (W03) is present in the sample as both a subadult and an adult.

Wolverine generally used habitats within the Alpine Tundra Zone in a lower proportion than available within their home ranges. Exceptions to this were adult females in season 2 (4 showed selection for AT habitats, 1 was neutral and 2 demonstrated relative avoidance), subadult females in season 2 and adult females in season 3. In both latter cases these wolverine on the whole used AT habitats in proportion to their availability within their home ranges. Adult females use AT habitats the most of any age/sex class, particularly within seasons 2 and 3. Habitats used particularly often include Alpine Meadow (AM), Alpine Shrubland (AS), Alpine Tundra (AT), and Alpine Unvegetated (AU) (Table 33).

Habitats within the BWBS zone were used in proportion to their availability by most age classes in most seasons. Subadult females and adult males, however, used BWBS habitats significantly more than their availability in season 1, and adult females, subadult females and adult males used BWBS habitats less than their availability in season 2. Although they used in BWBS habitats in proportion to availability, adult females were located in these habitats extensively within season 1. Adult males and subadult females also used habitats within this zone extensively during this season. BWBS habitats were used to a lesser extent by subadult males. Boreal White Spruce – Lodgepole Pine (BP) and Lodgepole pine habitats were the most heavily used habitats within this zone by all age and sex classes. Many other forested units were used to a lesser extent (Tables 33-36). Two locations were in non-forested habitats, one on a large lake (LL) and one on a transportation corridor (TC). Both of these were adult females.

Habitats within the ESSF zone were used less than available by all sex and age classes but adult females in season 1 (Table 29). Adult females for the most part used these habitats in proportion to availability (4 out of 7 wolverine). Two adult female wolverine used ESSF habitats less than their availability within home ranges and 1 wolverine used them in greater proportion than available during this season. ESSF habitats were primarily used more than available by subadult females in season 2 , less than available by subadult males and in proportion to availability by adult wolverine of both sexes (Table 30). Males used ESSF habitats less than available in seasons 3 and 4 while females were variable in their use (Table 31 and 32). All sex and age classes used a variety of habitats within the ESSF zone, however Engelmann Spruce – Subalpine Fir Dry Forested (EF) and Engelmann Spruce – Subalpine Fir Parkland (FP) were the most commonly used habitats (Tables 33-36). Many locations were within non-forested habitats including meadow, clearcut, avalanche tract, and subalpine meadow.

Table 29. Stand scale (within home range) selection for habitats within zones by transmittered wolverine for season 1. Numbers represent the number of animals demonstrating significant selection ($p < 0.05$) or avoidance of habitat.

	AT	BWBS	ESSF	SBS	SWB
Adult Female					
Avoid	7	1	2	2	
Neutral		4	4	3	
Select		2	1	1	
Subadult Female					
Avoid	5	1	6		2
Neutral	1		1	1	
Select		4		5	
Adult Male					
Avoid	9		9	1	1
Neutral	1	1	1	2	1
Select		9		3	
Subadult Male					
Avoid	5	2	5		1
Neutral		1			
Select		2		4	

Habitats within the SBS zone were selected by both sexes of subadult wolverine during season 1 (Table 29), while adults were more variable in their use of these habitats. During this season, two of seven adult females used SBS habitats less than available, 3 used them in proportion to availability and 1 used them greater than available. Three adult males used SBS habitats greater than their availability within home ranges, two used them in proportion to availability and 1 used them less than available. SBS habitats were used less than available by females during season 2, while males were more variable in the use of these habitats (Table 30). More subadults preferred SBS habitats during season 3 than avoided them, while adults were relatively indiscriminate in their use of these habitats in this season (Table 31). SBS habitats were avoided by females in season 4 and selected by males (Table 32). Habitat use within the SBS zone was more evenly distributed between habitat units than other zones (Tables 33-36). Habitats that were used extensively included Lodgepole Pine (LP), Subboreal White Spruce – Trembling Aspen (SA), White Spruce – Subalpine Fir (SF), Subboreal White Spruce – Lodgepole Pine (SL) and Hybrid White Spruce – Black Cottonwood Riparian (WR).

SWB habitats were used less than available within home ranges by all age and sex classes, however, this is influenced more by the relatively small amount of SWB habitat available for use rather than habitat use patterns (Tables 29-32). Table 37 summarizes selection of habitats within home ranges at a biogeoclimatic zone level for all sex and age classes of wolverine.

Table 30. Stand scale (within home range) selection for habitats within zones by transmittered wolverine in season 2. Numbers represent the number of animals demonstrating significant selection ($p < 0.05$) or avoidance of habitat.

	AT	BWBS	ESSF	SBS	SWB
Adult Female					
Avoid	2	6	1	5	
Neutral	1		4		
Select	4	1	2	1	
Subadult Female					
Avoid	2	5		4	2
Neutral	2		3	1	
Select	2		3		
Adult Male					
Avoid	5	6	3	2	2
Neutral	3	3	6	2	
Select	2	1	1	3	
Subadult Male					
Avoid	5	3	3	2	1
Neutral			1		
Select		2	1	2	

Table 31. Stand scale (within home range) selection for habitats within zones by transmittered wolverine for season 3. Numbers represent the number of animals demonstrating significant selection ($p < 0.05$) or avoidance of habitat.

	AT	BWBS	ESSF	SBS	SWB
Adult Female					
Avoid	1	2	2	1	
Neutral	3	2	1	2	
Select	1	1	2	1	
Subadult Female					
Avoid	5	2	2	1	1
Neutral					1
Select		1	2	2	
Adult Male					
Avoid	2	2	3	1	2
Neutral	2		1	1	
Select		2		1	
Subadult Male					
Avoid	2	2	2		
Neutral					

Select				2	

Table 32. Stand scale (within home range) selection for habitats within zones by transmittered wolverine for season 4. Numbers represent the number of animals demonstrating significant selection ($p < 0.05$) or avoidance of habitat.

	AT	BWBS	ESSF	SBS	SWB
Adult Female					
Avoid	2			1	
Neutral		1	1	1	
Select		1	1		
Subadult Female					
Avoid	3	1	1	3	2
Neutral	1		1		
Select		2	2		
Adult Male					
Avoid	2	1	2		1
Neutral	1	1	1		
Select		1		2	
Subadult Male					
Avoid	1	1	1		
Neutral					
Select				1	

Table 33. Seasonal distribution of broad ecosystem unit use for adult females. Numbers are numbers of locations.

		Season			
Zone	BEU	1	2	3	4
AT	AH		3	1	
	AM		6	3	
	AN			1	
	AS		10	4	1
	AT	5	13		
	AU	5	6	5	
	TA		3		
BWBS	BA	6	1		
	BL	1			
	BP	42	8	7	2
	LL	1			
	LP	16	3	2	3
	ME	1		1	
	PR	4	1		
	SA	1			
	SF	1			
	SK	3			
	TC	1			
	WR	1			
ESSF	AV			1	1
	CC	2			
	EF	52	33	7	3
	ER	3	1	2	
	FP	18	15	9	2
	LP	1	1	1	
	ME				
	SA	1			
SBS	BL	1			
	BP	1			
	CC	2		1	
	LP	5	1	1	
	MR		1		
	SA	5	1		
	SB	2			
	SF	11	2	1	
	SL	11		1	2
	SW	1			
	WR	5	8	1	

Table 34. Seasonal distribution of broad ecosystem unit use for subadult females. Numbers are numbers of locations.

		Season			
Zone	BEU	1	2	3	4
AT	AH		3		
	AM		1		
	AS		1	2	
	AT		3		1
	AU		1		2
	SM		1		
BWBS	BA	3			1
	BL	3			
	BP	13		1	3
	CC		1		
	LP	12		1	1
	ME	2			
	PR	2			
	SK			1	1
ESSF	AV				1
	BB		2		
	CC	1	1		
	EF	10	11	8	1
	ER		1		
	FP	2	14	3	1
	LP	4	1		1
	SF		3		
	SL		1		
	SM		1		
SBS	BL	5	1	1	
	CC	3	4		
	LP	6		2	1
	SA	4		1	1
	SF	2		1	
	SL	21	4	3	2
	WR	8			

Table 35. Seasonal distribution of broad ecosystem unit use for adult males. Numbers are numbers of locations.

		Season			
Zone	BEU	1	2	3	4
AT	AH		1		
	AM		1	3	
	AS		2	1	
	AT	2	3	2	
	AU	1	4	1	
	AV		1		
BWBS	BA	7	1	1	
	BB	2		1	
	BL	5		2	
	BP	40	7	7	4
	CC	3			
	LP	24	2	1	1
	PR	10		1	
	SA	2			
	SF	4			
	SK	2			
	SL	1			
	SW	1			
	WR	1			
ESSF	AV		1		
	CC		4		
	EF	12	16	10	4
	ER	1	1		1
	FP	3	7	5	1
	LP		2		
	ME	1			
SBS	BB	6			
	BL	1		1	
	CC	5	3		
	LP	2	2		
	ME	1			
	RE	3			
	SA	7	4	3	2
	SB				1
	SF	9	2	1	1
	SL	10	5	5	5
	TC		1		
	WR	4	2		2

Table 36. Seasonal distribution of broad ecosystem unit use for subadult males. Numbers are numbers of locations.

		Season			
Zone	BEU	1	2	3	4
AT	AH	2			
	AT	1			
	AU	1	1		
BWBS	AV	1			
	BB	2			
	BP	16	7	1	1
	LP	9	2		
	PR	4			
ESSF	AV	1			
	EF	5	3		
	ER	1			
	LP		1		
SBS	BB	1	1	1	1
	BL	3		1	
	CC	5	1	1	2
	LP	8	1	3	
	SA	6			2
	SB	1	1	1	
	SF	1	1	2	1
	SL	17	6	9	7
	SW				1
	TC	1			
	WR	6		3	1

Table 37. Selection summary of biogeoclimatic zones within wolverine home ranges.

Season	1	2	3	4
AT		Adult females		
BWBS	Subadult females Adult males			Adult females Subadult females
ESSF		Subadult females		Adult females
SBS	Subadult females Subadult	Subadult females Subadult	Subadult males	Adult males Subadult

	males	males		males

Female wolverines primarily use early and late successional habitats, while male wolverine activity is predominantly within late successional habitats (Tables 38-41). These patterns vary seasonally, with most of the early successional habitat use occurring during season 2, when wolverine make the most use of high elevation habitats. The majority of these locations are in herb/shrub and fir parkland habitats in the AT and high elevation ESSF zones. Most locations are in late successional stage habitats (particularly mature and old growth). Overall, more than half of all locations, for each sex and age class are in these seral stages. Relatively little use is made of mid-successional habitats by any wolverine.

Table 38. Adult female wolverines use of seral stages by season for all BEC zones (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	6	13	10	15	9
2	7	26	27	15	15
3a	2	7	8	10	5
3b	2	3	6	0	3
4	1	4	2	0	2
5	21	12	4	15	16
6	58	32	35	40	47
7	2	4	6	5	3

Table 39. Adult male wolverines use of seral stages by season for all BEC zones (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	3	13	2	0	4
2	4	12	13	3	6
3a	3	9	4	8	5
3b	6	12	7	0	6
4	4	1	5	5	4
5	30	19	7	8	22
6	43	22	41	49	40
7	8	13	21	27	13

Table 40. Subadult female wolverines use of seral stages by season for all BEC zones (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	1	8	0	18	4
2	5	36	0	0	12
3a	0	8	0	0	2
3b	3	8	0	0	4
4	1	3	0	0	1
5	32	5	33	18	25
6	47	33	58	64	46
7	10	0	8	0	6

Table 41. Subadult male wolverines use of seral stages by season for all BEC zones (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	6	0	0	0	4
3a	6	0	0	0	4
3b	0	0	0	0	0
4	3	10	0	0	4
5	24	50	17	0	27
6	59	30	33	0	49
7	3	10	50	100	12

When wolverine are in the AT zone, locations are evenly distributed between herb-dominated and shrub-dominated habitats (Tables 42-45). Adult females appear to use proportionately more herb dominated habitats in seasons 1 and 4, however at this level of detail small sample sizes preclude concrete conclusions.

Table 42. Seasonal use of the Alpine Tundra biogeoclimatic zone and associated seral stages by adult female radio-collared wolverines (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	100	39	42	75	52
2	0	47	33	0	34
3a	0	14	25	25	14

Table 43. Seasonal use of the Alpine Tundra biogeoclimatic zone and associated seral stages by adult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	33	62	17	0	50
2	67	23	83	100	42
3a	0	15	0	0	8

Table 44. Seasonal use of the Alpine Tundra biogeoclimatic zone and associated seral stages by subadult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	37	.	.	33
2	100	63	.	.	67
3a	0	0	.	.	0

Table 45. Seasonal use of the Alpine Tundra biogeoclimatic zone and associated seral stages by subadult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	.	.	.	0
2	100	.	.	.	100
3a	0	.	.	.	0

Adult females spend a considerable amount of time in early successional habitats when in the ESSF zone, primarily in Fir Parkland broad ecosystem units (Province of BC 1998) (Table 46). There is a marked increase in use of these habitats during seasons 3 and 4. Most locations, however, are in old successional habitats. There are locations in shrub dominated habitats during season 4, most of which are within avalanche track habitats. On average, 18% of adult male locations in the ESSF are in younger fir parkland type habitats while 68% are within mature and older seral habitats (Table 47). More use is made of early and mid-successional habitats during season 2 than during any other season.

Subadult female wolverine had a similar pattern of use of seral stages as adult females within the ESSF zone, however sample sizes limit the scope of conclusions (Table 48). Subadult male wolverine used only later successional habitats, but again, sample sizes are limiting (Table 49).

Table 46. Seasonal use of the Engelmann Spruce Subalpine Fir biogeoclimatic zone and associated seral stages by adult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	20	22	40	38	24
3a	6	0	5	13	4
3b	3	7	5	0	4
4	0	7	0	0	2
5	6	11	5	13	8
6	65	48	40	25	54
7	0	7	5	13	3

Table 47. Seasonal use of the Engelmann Spruce Subalpine Fir biogeoclimatic zone and associated seral stages by adult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	17	22	20	0	18
3a	6	13	0	0	7
3b	0	9	10	0	5
4	0	4	0	0	2
5	28	17	10	0	18
6	39	26	60	80	41
7	11	9	0	20	9

Table 48. Seasonal use of the Engelmann Spruce Subalpine Fir biogeoclimatic zone and associated seral stages by subadult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	50	2
2	14	43	0	0	25
3a	0	5	0	0	2
3b	0	0	0	0	0
4	5	5	0	0	4
5	36	5	0	50	21
6	36	43	100	0	42
7	9	0	0	0	4

Table 49. Seasonal use of the Engelmann Spruce Subalpine Fir biogeoclimatic zone and associated seral stages by subadult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	.	.	0
2	0	0	.	.	0
3a	0	0	.	.	0
3b	0	0	.	.	0
4	0	0	.	.	0
5	60	67	.	.	63
6	40	0	.	.	25
7	0	33	.	.	12

Habitat use by all age and sex classes in the lower elevation zones (SBS and BWBS) primarily occurred in successional stages 5, 6 and 7 (Tables 50-57), in spite of the presence of considerable areas of younger successional stages created by logging and wildfire.

Table 50. Seasonal use of the Sub-Boreal Spruce biogeoclimatic zone and associated seral stages by adult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	0	0	0	0	0
3a	3	0	0	0	2
3b	5	0	29	0	7
4	5	0	0	0	4
5	24	20	14	33	23
6	62	70	29	67	60
7	0	10	29	0	5

Table 51. Seasonal use of the Sub-Boreal Spruce biogeoclimatic zone and associated seral stages by adult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	3	4	0	0	2
2	1	0	0	0	1
3a	7	4	4	12	7
3b	11	17	8	0	10
4	5	0	12	8	6
5	21	26	8	12	18
6	38	22	27	36	34
7	14	26	42	32	23

Table 52. Seasonal use of the Sub-Boreal Spruce biogeoclimatic zone and associated seral stages by subadult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	0	0	0	0	0
3a	0	11	0	0	1
3b	6	33	0	0	8
4	0	0	0	0	0
5	34	11	50	0	31
6	47	45	50	100	49
7	13	0	0	0	10

Table 53. Seasonal use of the Sub-Boreal Spruce biogeoclimatic zone and associated seral stages by subadult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	.	0	.	0
2	0	.	0	.	0
3a	11	.	0	.	7
3b	0	.	0	.	0
4	0	.	0	.	0
5	0	.	20	.	7
6	78	.	40	.	64
7	11	.	40	.	21

Table 54. Seasonal use of the Boreal White and Black Spruce biogeoclimatic zone and associated seral stages by adult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	2	0	0	0	2
2	1	0	11	0	2
3a	0	10	0	0	1
3b	0	0	0	0	0
4	1	10	11	0	3
5	33	50	0	20	32
6	58	30	78	80	58
7	4	0	0	0	1

Table 55. Seasonal use of the Boreal White and Black Spruce biogeoclimatic zone and associated seral stages by adult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	3	0	0	0	1
3a	0	0	7	0	1
3b	2	20	7	0	3
4	4	0	0	0	3
5	39	30	7	0	33
6	51	40	71	83	53
7	4	10	7	17	5

Table 56. Seasonal use of the Boreal White and Black Spruce biogeoclimatic zone and associated seral stages by subadult female radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	6	0	0	17	7
2	6	0	0	0	4
3a	0	100	0	0	4
3b	0	0	0	0	0
4	0	0	0	0	0
5	28	0	33	17	25
6	60	0	33	66	57
7	0	0	33	0	4

Table 57. Seasonal use of the Boreal White and Black Spruce biogeoclimatic zone and associated seral stages by subadult male radio-collared wolverine (percent of locations).

	Season				
Seral Stage	1	2	3	4	Overall
1	0	0	0	0	0
2	5	0	0	0	4
3a	5	0	0	0	4
3b	0	0	0	0	0
4	5	14	0	0	7
5	26	43	0	0	29
6	58	43	0	0	50
7	0	0	100	100	7

Overall, wolverine showed similar patterns of use of seral stages within the AT biogeoclimatic zone (Table 58-61). In the ESSF zone, only subadult males made little use of Fir Parkland units (Table 59). This may be a strategy to avoid contact with dominant, aggressive males. This contact can often be lethal, particularly during season 2. Patterns of use were broadly similar in SBS and BWBS habitats (Tables 60,61).

Table 58. Seral stage use of the Alpine Tundra biogeoclimatic zone by radio-collared wolverine (percent of locations).

	Females		Males		
Seral Stage	Adult	Subadult	Adult	Subadult	Overall
1	52	33	50	0	49
2	34	67	42	100	40
3a	14	0	8	0	11

Table 59. Seral stage use of the Engelmann Spruce Subalpine Fir biogeoclimatic zone by radio-collared wolverine (percent of locations).

	Females		Males		
Seral Stage	Adult	Subadult	Adult	Subadult	Overall
1	0	2	0	0	<1
2	24	25	18	0	22
3a	4	2	7	0	4
3b	4	0	5	0	4
4	2	4	2	0	2
5	8	21	18	63	14
6	54	42	41	25	48
7	3	4	9	12	5

Table 60. Seral stage use of the Sub-Boreal Spruce biogeoclimatic zone by radio-collared wolverine (percent of locations).

	Females		Males		
Seral Stage	Adult	Subadult	Adult	Subadult	Overall
1	0	0	2	0	1
2	0	0	1	0	<1
3a	2	1	7	7	5
3b	7	8	10	0	9
4	4	0	6	0	2
5	23	31	18	7	21
6	60	49	34	64	44
7	5	10	23	21	17

Table 61. Seral stage use of the Boreal White and Black Spruce biogeoclimatic zone by radio-collared wolverine (percent of locations).

	Females		Males		
Seral Stage	Adult	Subadult	Adult	Subadult	Overall
1	2	7	0	0	1
2	2	4	1	4	2
3a	1	4	1	4	1
3b	0	0	3	0	2
4	3	0	3	7	3
5	32	25	33	29	32
6	58	57	53	50	55
7	1	4	5	7	4

A total of 89 site investigations were conducted between April 1996 and March 1999 (Tables 62,63). Intensive habitat use analyses via site investigations are the focus of the 1999/2000 and 2000/2001 field seasons. As a result, a summary of the limited site investigation data are presented.

Table 62. The number of site investigations of conducted for radio-collared wolverine in the Northern Wolverine Project study area, 1996-1999.

	Season				
Year	1	2	3	4	Total
1996	2	8	1	1	12
1997	23	8	4	1	36
1998	6	6	0	6	18
1999	4	10	0	9	23
Total	34	26	3	15	89

Table 63. Biogeoclimatic zone and season for site investigations (*n* = 89) conducted on radio-collared wolverine in the Northern Wolverine Project study area, 1996-1999.

Biogeoclimatic	Season				
Zone	1	2	3	4	All
SBSmk2	7	2	1	10	20
SBSwk2	6	4	0	4	14
SBSdk	0	1	0	0	1
BWBSdk1	14	7	0	1	22
ESSFmv3	7	9	2	2	20
AT	1	9	2	0	12
Total	33	31	5	17	89

The activity of wolverine was identified at most site investigations. More than one activity was identified at some site investigations (i.e. scavenging and bedding) (Table 64). The activity at many site investigations was unknown (*n*=27, 30.34 %). However, most of the site investigations (*n*=24, 26.97 %) at which the activity was unknown were conducted during Season 2 or Season 3. Seasons 2 and 3 are largely snow free. In general, researchers had much greater difficulty finding and interpreting sign of wolverine activity during snow free periods. Frequently there was little or no sign found at the site. During snow free periods wolverine are more difficult to track than larger heavier animals that are more likely to leave tracks or other sign such as broken vegetation or hair on branches. The ability to snow track greatly increased the likelihood that evidence to indicate the wolverine's activity and scats would be found. Furthermore, site investigations were easier to conduct when there was snow on the ground because evidence such as hide or blood generally stand out in snow. Whereas, in summer evidence was frequently covered by vegetation or camouflaged by the ground.

Scavenging was documented at 16 site investigations. Predation was documented at six site investigations . Moose was the major scavenged item documented at 12 site investigations . Black bear, unknown ungulate, unknown animal and human refuse were documented in one site investigation each. Caribou was the prey item documented at three site investigations . Marmot, beaver and grouse predation were each documented at one site investigation. Foraging was documented three times, twice for snowshoe hare and once for marmot .

Table 64. Activity and season of activity of site investigations (n=89) conducted for wolverine in the Northern Wolverine Project study area, 1996-1999.

	Season					
Activity [1]	1	2	3	4	Total	%
Unknown	2	20	4	1	27	30.34
Scavenge	9	3	0	4	16	17.98
Predation	4	1	0	1	6	6.74
Foraging	2	0	0	1	3	3.37
Den (maternal)	5				5	5.61
Den (other)	7	0	0	0	7	7.87
Bed	6	1	0	4	11	12.36
Travel	9	5	1	4	19	21.35
Marking	0	0	0	1	1	1.12
Mortality	2	5	0	1	8	8.99
Collar Drop	2	11	4	2	19	21.34

[1] More than one activity was recorded for some site investigations.

We were frequently unable to find evidence to indicate whether scavenging sites were also cache sites that had been made by the wolverine at an earlier date. Site investigations identified as scavenge sites may also be cache sites that were used previously by the wolverine. Telemetry locations of wolverine using the same general area on subsequent dates indicate that wolverine likely use cache sites more frequently than documented by our site investigations. Site investigations in which predation was identified may also be under represented because the cause of death for many animals could not be determined. Therefore, some site investigations in which the activity was identified as scavenging may have actually been predation. Additional scavenging and predation observations have been observed but are not documented in the detailed site investigation process. These are included in the food habits summary.

Five site investigations were conducted at maternal dens (Table 65). One maternal den was documented for W02 in 1996. Two maternal dens were documented in 1997 (W10 and W16) and two maternal dens were documented in 1998 (W02 and W13). No maternal dens were located in 1999. Wolverine W02 was radio-tracked to a suspected maternal den site on April 18, 1996. This wolverine had been located in the same subalpine bowl on 2 other occasions. When this location was visited this female was in the den. A total of four den sites were found within a 50m radius at this same location. Three had been previously occupied and were all under the snow associated with coarse woody debris such as logs or dead trees. The fourth den site was occupied and it was estimated to have been used for at least 3 days. W02 was in a cavity approximately 6-7 m from the den entrance and under approximately 3 m of snow. No attempt was made to disturb her. Wolverine W10 was tracked to a maternal den site in March of 1997. This site was located on the edge of a subalpine meadow. W10 had been located consistently in this locale in

March 1996, however no den was found at that time. The 1997 den was subnivean, located under a fallen tree. Wolverine W16 was located at a den in a subalpine bowl in April 1997. This den site was in forested habitat and was subnivean. Structure of the den was formed by a mass of blowdown formed by an old avalanche. W02 was located in a den site in 1998 in close proximity to her 1996 den. The den was under coarse woody debris. W13 was tracked to a den site in 1998 associated with large talus material. All maternal dens were in the ESSFmv3 biogeoclimatic subzone/variant. Three maternal dens were in the Engelmann Spruce – Subalpine Fir Dry (EF) Broad Ecosystem Unit. Two maternal dens were in the Engelmann Spruce – Subalpine Fir Parkland (FP) Broad Ecosystem Unit. Three dens were associated with logs or piles of coarse woody debris (CWD). One den was associated with a large rock and one den was in unknown structure. All dens were between 1550 meters and 1775 meters elevation. Dens were located in a variety of seral stages including pole/sapling, mature and old. Dens were also located on variable slopes 5% to 49%. There was also a wide variation in aspects among dens. However, the den with the coldest aspect (10 degrees) was on a relatively gentle slope (5%).

Table 65. Summary of maternal den sites of radio-collared wolverine in the Northern Wolverine Project study area, 1996-1999.

Wolverine	**Year**	**BEC**[1]	**BEU**	**Elev. (m)**	**Den Type**	**Seral Stage**[2]	**Slope (%)**	**Aspect**
W02	1996	ESSFmv3	FP	1550	Unk	3	5	10
W10	1997	ESSFmv3	EF	1560	Log	7	11	270
W16	1997	ESSFmv3	EF	1775	CWD	6	21	90
W13	1998	ESSFmv3	FP	1740	Rock	4	49	144
W02	1998	ESSFmv3	EF	1555	CWD	6	19	206

[1] ESSFmv3 = Engelmann Spruce Subalpine Fir moist very cold.
[2] Seral Stages: 4 = pole sapling, 6 = mature forest

4.3.4 Snow Tracking

Wolverines were tracked 32 times for a total of 41478 metres for an average of 1296 metres per tracking session. Travel was the dominant behaviour for most of the snow tracking (Table 66). Activity (as measured by an activity index of the ratio of the distance tracked to linear distance traveled) was greatest during foraging behaviour and in seral stage 7 (old-growth) (Tables 66 and 67). Most wolverine travel was recorded in seral stages 5 and 6 (Table 67). A total of 45 significant identifiable events were recorded during snow tracking (Table 68) within a variety of broad ecosystem units and seral stages (Table 69). Highest activity indices were recorded in riparian forest (CR,PR,WR,ER), upland forest (BA,BP,LP,EF,SA,SB,SF,SL) and regenerating clearcut (CC) broad ecosystem units (Table 70). These also represented 61.3, 19.8 and 11.6 percent of wolverine travel sampled. Most wolverine tracking and activity was in seral stages 5, 6 and 7. This is in accordance with stand level habitat analyses. However there was a considerable amount of activity in regenerating clearcuts. This was not evident in other analyses. Wolverine may have a tendency to move into cover when being located from the air, thus skewing the aerial location data somewhat. In addition snow tracking was restricted to low elevation (mostly SBS) habitats with extensive forest harvesting relative to the overall study area. As such the likelihood of sampling tracks in clearcut habitats is greater.

Table 66. Distance of wolverine travel and activity index by dominant behaviour recorded during travel.

Dominant Segment Behaviour	Total Distance Traveled (m)	Activity Index
Travel	28817	1.06
Foraging	9628	1.39
Scavenging	3033	1.03

Table 67. Distance of wolverine travel and activity index by seral stage.

Seral Stage	Total Distance Traveled (m)	Activity Index
0	2317	1.02
1	525	1.0
2	10	1.0
3	6212	1.05
4	2003	1.01
5	8651	1.13
6	18841	1.09
7	2012	1.37

Table 68. Wolverine behaviours recorded during snow-tracking.

Predation	Scavenging	Bedding	Marking
8	12	14	11

Table 69. Wolverine behaviours recorded by broad ecosystem unit and seral stage.

Seral Stage	Broad Ecosystem Unit	CC	LP	SA	SF	SL	EF
0							
1							
2							
3		S – 1 P – 4 B – 4 M - 2					
4			S – 1			P – 1	
5			S - 4	P – 1			
6				P – 1	S – 1	S - 3 P – 1 B – 5 M – 2	S –1 B – 2 M – 7
7					S – 1 B - 1		

S=Scavenging; P=Predation; B=Bedding; M=Marking

Table 70. Distance of wolverine travel and activity index by broad ecosystem unit and seral stage.

Broad Ecosystem Unit	Total Distance Travelled (m)	Activity Index
TC	1899	1.0
TR	20	1.13
GB	580	1.0
IN	41	1.0
SP	20	1.0
FS	60	1.2
LS	63	1.0
CC	4536	1.39
CC/BL Ecotone	286	1.0
ME	10	1.0
SW	107	1.0
BB	71	1.0
CR	80	1.07
PR	425	1.13
ER	2790	1.21
WR	4900	1.22
BA	50	1.0
BP	649	1.06
LP	6600	1.1
LP/Creek Ecotone	100	1.0
EF	752	1.0
SA	3205	1.01
SB	1433	1.09
SF	2468	1.08
SL	8087	1.17

4.4 Food Habits

Stomachs from 33 wolverine and 72 wolverine scats were analyzed (Table 71). Most samples were from seasons 1 and 4. Seasons 2 and 3 have fewest samples as there is no trapping during these periods and these seasons are relatively snow free making tracking wolverine and finding scats more difficult. The commercial trapping season for wolverine occurs in the latter part of season 3 and all of season 4.

Stomachs were empty 12.1% of the time and 8.6% of scats had no identifiable remains after re-hydrating, washing and screening (Table 71). Only 21.2% of stomachs had one item while 58.8% of scats had only one food item. Tables 72-75 summarize the percent occurrence of food items in samples for each season.

Table 71. Frequency of number of food items found in wolverine stomach and scats (percent).

Number of Items	Stomach (n = 33)	Scats (n = 72)
Empty	12.1	8.6*
1	21.2	58.8
2	24.2	27.9
3	24.2	5.9
4	9.1	0
Vegetation only	3.0	0
Fluid only	3.0	n/a
Not analyzed	3.0	n/a

* - no identifiable remains after washing and sieving process

Scats from maternal den sites were separated from the rest of the scats in Tables 72 and 73 due to the marked difference in composition. Moose occur in more than 50% of seasonal samples except in den site scats and samples from season 2. Scats from den sites are notable for the high frequency in which caribou occurs in them. Caribou occur in samples primarily in season 1 with 1 occurrence in season 4. There is a much lower diversity of food items in scats from den sites than in all other samples (Table 73). Wolverine hair appears in an average of just less than 10% of all samples. Most other food items occur in low frequencies in some or all seasons. Hoary marmots (*Marmota caligata*) are an exception to this. They only occur in scat and stomach samples in season 2, but at a frequency of 37.5% of all samples (Table 72). All of these are from females. As a component of food items found in female samples, marmots occur in 60% of season 2 samples (Table 73). Beaver (*Castor canadensis*) occur in very high frequencies in seasons 3 and 4.

Foraging events recorded throughout the study from aerial observations, site investigations and incidental observations (Table 76) indicate that moose were consistently fed upon in all seasons, however they are particularly prevalent as a foraging item in season 1. Incidents of wolverine foraging on caribou were recorded during season 1 with 1 event each in seasons 2 and 3. Foraging on marmots was only recorded in season 2. All records of marmot foraging were of female wolverine.

Table 72. Food items found in stomach contents and scats of all wolverine by season (numbers are percent occurrence in total seasonal samples).

	Season					
Food Item	1		2	3	4	Unknown
	Denning Females n = 15	Other n = 39	n = 8	n = 8	n = 19	n = 3
Alces alces	20	66.7	37.5	62.5	52.6	33.3
Rangifer tarandus	73.3	10.3	0	0	5.3	0
Unknown Cervidae	20	20.5	12.5	0	5.3	33.3
Gulo gulo	20	2.6	12.5	25	21.1	33.3
Unknown Mustelidae	0	7.7	12.5	0	0	0
Lepus americanus	0	7.7	12.5	0	10.5	0
Unknown Arvicolidae	0	7.7	12.5	25	0	33.3
Castor canadensis	0	10.3	0	37.5	57.9	33.3
Peromyscus maniculatus	0	7.7	12.5	12.5	5.3	33.3
Erithizon dorsatum	0	0	0	0	5.3	0
Marmota caligata	0	0	37.5	0	0	0
Glaucomys sabrina	0	0	0	0	5.3	0
Tamasciurius hudsonicus	0	5.1	0	0	21.1	0
Unknown Zapodidae	6.7	7.7	0	0	10.5	0
Unknown Rodentia	0	2.6	12.5	0	0	0
Sorex monticolus	0	5.1	0	0	0	0
Unknown Soricidae	0	5.1	0	0	0	0
Unknown Insectivora	0	2.6	0	0	0	0
Unknown Hair	20	20.5	50	50	68.4	33.3
Bonasa umbellus	0	0	0	12.5	5.3	0
Lagopus spp.	0	0	0	12.5	0	0
Unknown Fish	0	0	0	0	5.3	0
Vegetation	0	20.5	25	75	42.1	0
Trap Debris	0	15.4	0	0	5.3	0
Garbage	0	0	0	12.5	0	0
Total Food Items[*]	3	9	5	7	11	4

[*]- wolverine hair, vegetation and trap debris are not included as potential food items. Hairs identified to family or order are only included if there are no other items in those groups.

Large ungulates play a very important role in wolverine foraging ecology (Banci 1987, Copeland 1996, Gardner 1985, Magoun 1987). Moose are particularly prevalent in both scat and stomach samples and observed foraging events. Caribou appear, however to be differentially important to adult females with kits than other sex and age classes. Scats found in maternal den sites are dominated by caribou remains, with a small component of

Table 73. Food items found in stomach contents and scats of female wolverine by season (numbers are percent occurrence in total seasonal samples).

	Season				
Food Item	1		2	3	4
	Denning Females n = 15	Other n = 19	n = 5	n = 4	n = 5
Alces alces	20	63.2	20	75	20
Rangifer tarandus	73.3	15.8	0	0	0
Unknown Cervidae	20	21.1	0	0	0
Gulo gulo	20	5.3	20	0	0
Unknown Mustelidae	0	0	20	0	0
Lepus americanus	0	0	20	50	20
Unknown Arvicolidae	0	10.5	20	0	0
Castor canadensis	0	0	0	50	80
Peromyscus maniculatus	0	5.3	0	0	0
Erithizon dorsatum	0	0	0	0	0
Marmota caligata	0	0	60	0	0
Glaucomys sabrina	0	0	0	20	0
Tamasciurius hudsonicus	0	5.3	0	0	40
Unknown Zapodidae	6.7	15.8	0	0	0
Unknown Rodentia	0	5.3	0	0	0
Sorex monticolus	0	5.1	0	0	0
Unknown Soricidae	0	10.5	0	0	0
Unknown Insectivora	0	5.3	0	0	0
Unknown Hair	20	0	20	75	80
Bonasa umbellus	0	0	0	25	20
Lagopus spp.	0	0	0	25	0
Unknown Fish	0	0	0	0	0
Vegetation	0	10.5	0	100	20
Trap Debris	0	15.8	0	0	0
Garbage	0	0	0	0	0
Total Food Items[*]	3	7	4	6	5

[*]- wolverine hair, vegetation and trap debris are not included as potential food items. Hairs identified to family or order are only included if there are no other items in those groups.

Table 74. Food items found in stomach contents and scats of male wolverine by season (numbers are percent occurrence in total seasonal samples).

	Season				
Food Item	1	2	3	4	Unknown
	n = 15	n = 2	N = 4	n = 12	N = 1
Alces alces	73.3	100	50	66.7	100
Rangifer tarandus	0	0	0	0	0
Unknown Cervidae	16.7	0	0	0	0
Gulo gulo	6.7	0	50	33.3	100
Unknown Mustelidae	20	0	0	0	0
Lepus americanus	20	0	0	8.3	0
Unknown Arvicolidae	6.7	0	0	0	0
Castor canadensis	20	0	25	58.3	100
Peromyscus maniculatus	13.3	0	25	0	100
Erithizon dorsatum	0	0	0	8.3	0
Marmota caligata	0	0	0	0	0
Glaucomys sabrina	0	0	0	0	0
Tamasciurius hudsonicus	6.7	0	0	16.7	0
Unknown Zapodidae	0	0	0	8.3	0
Unknown Rodentia	0	0	0	0	0
Sorex monticolus	0	0	0	0	0
Unknown Soricidae	0	0	0	0	0
Unknown Insectivora	6.7	0	0	0	0
Unknown Hair	40	50	25	41.7	100
Bonasa umbellus	0	0	0	0	0
Lagopus spp.	0	0	0	0	0
Unknown Fish	0	0	0	8.3	0
Vegetation	40	50	50	50	0
Trap Debris	20	0	0	8.3	0
Garbage	0	0	25	0	0
Total Food Items[*]	7	1	4	7	3

[*]- wolverine hair, vegetation and trap debris are not included as potential food items. Hairs identified to family or order are only included if there are no other items in those groups.

moose remains. Scats from maternal den sites also have a lower diversity of food items. This may increase the importance of caribou to denning females at this time. All other scats in season 1 were dominated by moose. This is consistent with habitat use patterns in this season. Adult females are found on average at higher elevations. Den sites are located at elevations where caribou are also found. Adult females, therefore, may be more likely to encounter caribou hunting and scavenging opportunities during this time than

Table 75. Food items found in scats of unknown wolverine by season (numbers are percent occurrence in total seasonal samples).

	Season				
Food Item	1	2	3	4	Unknown
	n = 5	n = 1	N = 0	n = 2	n = 2
Alces alces	60	0		50	0
Rangifer tarandus	20	0		50	0
Unknown Cervidae	0	100		0	50
Gulo gulo	20	0		0	0
Unknown Mustelidae	0	0		0	0
Lepus americanus	0	0		0	0
Unknown Arvicolidae	0	0		0	50
Castor canadensis	20	0		0	0
Peromyscus maniculatus	0	100		50	0
Erithizon dorsatum	0	0		0	0
Marmota caligata	0	0		0	0
Glaucomys sabrina	0	0		0	0
Tamasciurius hudsonicus	0	0		0	0
Unknown Zapodidae	0	0		50	0
Unknown Rodentia	0	100		0	0
Sorex monticolus	0	0		0	0
Unknown Soricidae	0	0		0	0
Unknown Insectivora	0	0		0	0
Unknown Hair	40	100		100	0
Bonasa umbellus	0	0		0	0
Lagopus spp.	0	0		0	0
Unknown Fish	0	0		0	0
Vegetation	0	100		50	0
Trap Debris	0	0		0	0
Garbage	0	0		0	0
Total Food Items[*]	3	2		4	2

[*]- wolverine hair, vegetation and trap debris are not included as potential food items. Hairs identified to family or order are only included if there are no other items in those groups.

other sex and age classes. Wolverine are capable of killing caribou (Hatler 1989). In this study wolverine have been recorded killing caribou on 6 occasions resulting in the death of 7 caribou. Female wolverine were responsible for 4 of these predations. All predated caribou for which long bones remained appeared to be in very poor conditioned. Bone marrow fat content ranged from 5-8%. Marmots also appear to be disproportionately important in the diet of female wolverine during season 2. During this time females are provisioning kits that are undergoing their greatest period of growth. This is consistent with habitat use of adult females during this period. Adult females are found on average at a highest elevations during this season. Magoun (1987) also reported that ground dwelling sciurids were a seasonally important part of wolverine diets.

Table 76. Number of foraging occurrences recorded by season (includes aerial telemetry observations, site investigations, snow trailing events and incidental observations).

	Season			
Food Item	1	2	3	4
Alces alces	22	1	2	3
Rangifer tarundus	8	1	1	0
Marmota caligata	0	5	0	0
Castor canadensis	1	0	0	0
Ursus americanus	0	0	1	0
Martes pennanti	1	0	0	0
Bonasa umbellus	2	0	0	0
Unknown ungulate	0	0	0	1
Garbage/soap	1	0	0	0

The diversity of prey found in samples and at foraging sites indicates that wolverine spend considerable time hunting as well as scavenging. Smaller prey occur in lower frequencies in samples than do cervids. However, as scats have on average less items found in them than do stomachs, and cervid hair is more robust and will likely remain intact throughout the digestive process better than small mammal hair, small mammal frequencies may be under-represented in scats. Banci (1987) noted that frequency, however, over-estimates the importance of small prey.

The high frequency of beaver in samples in seasons 3 and 4 may be an artifact of wolverine feeding upon trapper bait, particularly during season 4 when beavers are safely ensconced within lodges for the winter. The inclusion of trapper bait as a “natural food” in a scavenger’s lifestyle is debatable. The presence of wolverine hair in samples is likely from grooming. Although we have evidence of interspecific conflicts resulting in mortalities, there is no evidence of wolverine cannabalizing other wolverine.

4.5 Marmot Abundance and Habitat Suitability

Results are summarized for the 1998 and 1999 field seasons. A total of 46.2 kilometers of transects were surveyed in 1998 and 1999 (1998 =16.882 kilometers and 1999 = 30.390 kilometers; Tables 77-79). Along these transects 160 marmot burrows were recorded (1998 =70 and 1999 = 90). Burrows were recorded in six of seven vegetation types. No marmot burrows were documented in the unvegetated habitat type. More burrows were documented per 100 meters of habitat in 1998 (0.42/100 m) than in 1999 (0.31/100m). Burrows were documented on class one (0-20 degrees) slopes or class two slopes (21 to 40 degrees) (Tables 80-82). In 1998, burrows were split evenly between slope class one (0.41/100 m) and slope class two (0.42/100 m). In 1999, more burrows were documented in slope class one (0.37/100 m) than in slope class two (0.24/100m). No marmot burrows were documented on slope class three slopes (41-60 degrees). More marmot burrows were documented on cool aspects (292.5-67.5 degrees) in 1998 (0.84/100 m) and 1999 (0.44/100 m) (Tables 83-85). Neutral aspects (67.5 – 112.5 degrees & 247.5 – 292.5 degrees) had the second highest abundance of burrows in 1998 (0.40/100 m) and 1999 (0.34/ 100m). Warm aspects (292.5 – 67.5 degrees) had the lowest abundance of burrows in 1998 (0.22/100 m) and 1999 (0.19/100 m).

The overall results indicated that meadow is most heavily used followed by tundra and talus. The greatest difference among years appeared to be in shrubland and talus habitats. There were relatively fewer marmot burrows in shrubland habitat in 1998 (0.04/100 m) compared to 1999 (0.36/100 m). There were relatively more marmot burrows in talus habitat in 1998 (1.10/100 m) compared to 1999 (0.20/100 m). The 1998 results indicated that talus, meadow and tundra, respectively, appeared to be most heavily used, whereas, the 1999 results indicated that meadow, tundra and shrubland, respectively, appeared to be most heavily used. Our general observations indicate that marmot burrows were frequently in close proximity to alpine meadows regardless of habitat type. In addition, marmot burrows were often associated with large rocks. The proximity of meadows and large rocks likely had a major influence on marmot habitat selection for burrows. In 1999, fifty of ninety marmot burrows were located under rocks. These burrows were frequently excavated in earth under rocks. Of the burrows under rocks only seven were in ribbon talus, whereas 43 were in other vegetated habitat types. Identifying the presence of meadows and large rocks will also likely be important to assessing marmot habitat suitability.

The following recommendations were given for the habitat suitability fieldwork in 1999 (Reid 1999):

1. more sampling in slope class 3;
2. more sampling in talus on warm aspects and parkland and shrubland on cold aspects.

Only 385 meters of slope class 3 was sampled in 1999. The relatively low representation of slope class 3 was partially because of safety issues for field staff working alone, as in 1998, and partially because of efforts to increase representation of meadow, talus and parkland habitats, which are less common in slope class three. Greater effort was put into sampling talus on warm aspects in 1999 (2065 m) compared to 1998 (56 m). Greater effort was also put into sampling parkland and shrubland on cold aspects in 1999. However, parkland representation is still relatively low for cold aspects. This may reflect a relatively low occurrence of parkland on cold aspects.

Further studies should investigate the effect of the proximity of meadows to marmot burrows on the ability to predict habitat suitability. Further recommendations for sampling may be identified following further data analysis using a transect data analysis program (Burnham, Anderson and Laake 1980).

Table 77. The vegetation type, distance traversed, and number of burrows observed in 1998 in the Wolverine Mountains.

Vegetation Type	1998 Distance Traversed (m)	1998 # of Burrows Observed	1998 # of Burrows per 100m of Habitat
Parkland	5390	7	0.13
Ribbon Talus[1]	-	-	-
Extensive Talus[1]	-	-	-
Talus[1]	1365	15	1.10
Alpine Tundra	4798	26	0.54
Alpine Meadow	2848	21	0.74
Alpine Shrubland	2481	1	0.04
Unvegetated[1]	-	-	-
Total	16,882	70	0.42

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 78. The vegetation type, distance traversed, and number of burrows observed in 1999 in the Wolverine Mountains.

Vegetation Type	1999 Distance Traversed (m)	1999 # of Burrows Observed	1999 # of Burrows per 100m of Habitat
Parkland	4510	3	0.0665
Ribbon Talus[1]	4362	10	0.2292
Extensive Talus[1]	538	0	0
Total Talus[1]	4900	10	0.2041
Alpine Tundra	9561	37	0.3870
Alpine Meadow	3211	15	0.4671
Alpine Shrubland	6963	25	0.3590
Unvegetated	245	0	0
Total	29390	90	0.3062

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 79. The vegetation type, total distance traversed, and total number of burrows observed in 1998 and 1999 in the Wolverine Mountains.

Vegetation Type	1998/99 Distance Traversed (m)	1998/99 # of Burrows Observed	1998/99 # of Burrows per 100m of Habitat
Parkland	9900	10	0.1010
Total Talus[1]	6265	25	0.3990
Alpine Tundra	14359	63	0.4387
Alpine Meadow	6059	36	0.5942
Alpine Shrubland	9444	26	0.2753
Unvegetated	245	0	0
Total	46272	160	0.3458

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 80. The vegetation type, distance traversed by slope class, and number of burrows observed by slope class in 1998 in the Wolverine Mountains.

Vegetation Type	1998 Distance Traversed by Slope Class			1998 # of Burrows by Slope Class			1998 # of Burrows Per 100 m Slope Class		
	1	2	3	1	2	3	1	2	3
Parkland	2933	2451	0	2	5	0	0.07	0.20	0
Talus[1]	250	1115		4	11		1.60	0.99	
Alpine Tundra	2574	2224	0	15	11	0	0.82	0.52	0
Alpine Meadow	2079	769	0	17	4	0	0.06	0.00	0
Alpine Shrubland	1661	820	0	1	0	0	0.68	0.50	0
Unvegetated	0	0	0	0	0	0	0	0	0
Total	9497	7385	0	39	31	0	0.41	0.42	0

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 81. The vegetation type, distance traversed by slope class, and number of burrows observed by slope class in 1999 in the Wolverine Mountains.

Vegetation Type	1999 Distance Traversed by Slope Class			1999 # of Burrows by Slope Class			1999 # of Burrows Per 100 m Slope Class		
	1	2	3	1	2	3	1	2	3
Parkland	2095	2334	81	2	1	0	0.0955	0.0448	0
Ribbon Talus[1]	1837	2498	27	5	5	0	0.2722	0.2002	0
Extensive Talus[1]	245	293	0	0	0	0	0	0	0
Total Talus[1]	2082	2791	27	5	5	0	0.2402	0.1791	0
Alpine Tundra	4706	4792	63	16	21	0	0.3400	0.4382	0
Alpine Meadow	2397	814	0	13	2	0	0.5423	0.2457	0
Alpine Shrubland	3008	3741	214	18	7	0	0.5984	0.1871	0
Unvegetated	100	145	0	0	0	0	0	0	0
Total	14388	14617	385	54	36	0	0.3753	0.2463	0

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 82. The vegetation type, distance traversed by slope class, and number of burrows observed by slope class in 1998 and 1999 in the Wolverine Mountains.

Vegetation Type	1998/99 Distance Traversed by Slope Class			1998/99 # of Burrows by Slope Class			1998/99 # of Burrows Per 100 m Slope Class		
	1	2	3	1	2	3	1	2	3
Parkland	5028	4785	81	4	6	0	0.0796	0.1253	0
Talus[1]	2332	3906	27	9	16	0	0.3859	0.0410	0
Alpine Tundra	7280	7016	63	31	32	0	0.4258	0.4561	0
Alpine Meadow	4476	1583	0	30	6	0	0.6702	0.3790	0
Alpine Shrubland	4669	4561	214	19	7	0	0.4069	0.1535	0
Unvegetated	100	145	0	0	0	0	0	0	0
Total	23885	21996	385	93	67	0	0.3894	0.3046	0

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 83. The vegetation type, distance traversed by aspect class, and number of burrows observed by aspect class in 1998 in the Wolverine Mountains.

Vegetation Type	1998 Distance Traversed by Aspect Class			1998 # of Burrows by Aspect Class			1998 # of Burrows Per 100 m Aspect Class		
	W	N	C	W	N	C	W	N	C
Parkland	3031	1979	380	0	6	1	0	.30	.26
Talus[1]	56	646	663	2	2	11	3.57	0.31	1.66
Alpine Tundra	1961	982	1855	8	3	15	.41	.31	.81
Alpine Meadow	1447	392	1009	7	7	7	.48	1.79	.70
Alpine Shrubland	1815	546	120	1	0	0	.06	0	0
Unvegetated	0	0	0	0	0	0	0	0	0
Total	8310	4545	4027	18	18	34	0.22	.40	.84

[1]ribbon talus, extensive talus and unvegetated habitats were identified as talus collectively in 1998, and differentiated in 1999.

Table 84. The vegetation type, distance traversed by aspect class, and number of burrows observed by aspect class in 1999 in the Wolverine Mountains.

Vegetation Type	1999 Distance Traversed by Aspect Class			1999 # of Burrows by Aspect Class			1999 # of Burrows Per 100 m Aspect Class		
	W	N	C	W	N	C	W	N	C
Parkland	3178	391	941	1	2	0	.0315	.5115	0
Ribbon Talus[1]	1916	908	1538	2	3	5	.1044	.3304	.3251
Extensive Talus[1]	149	157	232	0	0	0	0	0	0
Total Talus[1]	2065	1065	1770	2	3	5	.0969	.2817	.2825
Alpine Tundra	3351	1968	4242	6	8	23	.1791	.4065	.5422
Alpine Meadow	1569	878	764	4	2	9	.2550	.2278	1.178
Alpine Shrubland	2849	1710	2404	11	6	8	.3861	.3509	.3328
Unvegetated	51	168	26	0	0	0	0	0	0
Total	13063	6180	10147	24	21	45	.1837	.3398	.4435

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

Table 85. The vegetation type, total distance traversed by aspect class, and total number of burrows observed by aspect class in 1998 and 1999 in the Wolverine Mountains.

Vegetation Type	1998/99 Distance Traversed By Aspect Class			1998/99 # of Burrows by Aspect Class			1998/99 # of Burrows Per 100 m Aspect Class		
	W	N	C	W	N	C	W	N	C
Parkland	6209	2370	1321	1	8	1	.0161	.3376	.0757
Talus[1]	2121	1554	2433	4	5	16	.1885	.3218	.6576
Alpine Tundra	5312	2950	6097	14	11	38	.2636	.3729	.6232
Alpine Meadow	3016	1270	1773	11	9	16	.3647	.7087	.9024
Alpine Shrubland	1815	2256	2524	12	6	8	.6612	.2660	.3170
Unvegetated	51	168	26	0	0	0	0	0	0
Total	18524	10568	14174	40	41	79	0.2160	.3880	0.5574

[1]ribbon talus, extensive talus and unvegetated habitats were identified collectively as talus in 1998, and differentiated in 1999.

In 1998, a minimum of 21 marmots was observed in three observation polygons (Tables 81,82). In 1999, a minimum of 21 marmots was observed in ten observation polygons (Table 86). In 1998, polygons were selected for testing the feasibility of identifying individuals to estimate marmot abundance. In 1999, polygons were randomly selected. Marmots were identified in only four of ten polygons. Two polygons had less than nine hours of observation. Polygon # 24 had two- three hour morning observation sessions. Weather was not considered a limiting factor during these observations. Therefore, it is believed that most of the marmots were likely observed. More marmots were identified during morning observation sessions than afternoon observation sessions. Polygon # 68 had only one afternoon observation session before it was discontinued because time constraints created by the decision to ensure that each polygon would have a minimum of two morning observation sessions.

Table 86. Minimum number of marmots observed per observation polygon in 1999 in the Wolverine Mountains, Northern Wolverine Project.

Polygon #	Hours Observed	# of Young of Year	# of Yearlings	# of Adults	Total
14	10.75		3	6	9
24	6	3	0	1	4
55	9.75	2	0	3	5
60	10.85	0	1	2	3
68[1]	5.50	0	0	0	0
77	11.20	0	0	1	0
104	9.00	0	0	0	0
106	11.00	0	0	0	0
113	9.20	0	0	0	0
123	9.00	0	0	0	0

[1]Observation was one afternoon session. Observation was discontinued because of time constraints.

4.6 Populations Parameters

Survivorship rates were 65% overall for radio-transmittered wolverine (Table 87). Survivorship rates were highest for adult females and lowest for subadult males. Survivorship rates for females were greater than corresponding rates for males. Survivorship rates reported in Table 1 for wolverine in the study area are based on mortalities of known wolverine while they were being monitored (Table 88) and don’t include additional known mortalities of unmarked wolverine within the study area (Table 89). There were eleven mortalities of radio-collared study animals from 1996-1999 (Table 89). There were an additional two capture related mortalities. There were 12 additional mortalities recorded of unmarked wolverine (Table 89). Most mortalities occurred in seasons 1 and 2. All wolverine killed by another wolverine died in season 2, and all of these mortalities were male. The sources for all known mortalities were 13 trapper related, 1 logging truck, 2 capture-related mortalities, 3 killed by other wolverine, 1 killed by unknown animal, 2 unknown cause and 1 unknown natural cause (Tables 88,89).

Adult females who occupied high elevation dens (and thus were strongly suspected to have litters, although we were unable to confirm this) or known to have produced litters in 8 of the 16 periods when they were monitored (Table 90). Litter sizes based on embryos or counts of corpora lutea in trapper submitted carcasses averaged 3, based on very limited data (Table 91).

Survivorship rates are very low for a species with a reportedly low reproduction rate. Reproductive data necessary to interpret population growth rates are very limited. These data will be pursued in future field seasons.

Table 87. Survivorship rates of radio-transmittered wolverine.

Age and Sex Class	Survivorship Rate (percent +/- 95% C.L.
All Wolverine	0.64724 +/- 0.17063
All Females	0.74786 +/- 0.24491
All Males	0.52879 +/- 0.23859
Adult Females	0.90000 +/- 0.15606
Subadult Females	0.60000 +/- 0.41616
Adult Males	0.65476 +/- 0.24753
Subadult Males	0.20833 +/- 0.20833

Table 88. Mortalities of radio collared wolverine from 1996-1999.

Wolverine	Sex	Age Class	Mortality Source	Season
W01	Female	Subadult	Trapper kill out of season	1
W08	Female	Adult	Trapper kill	1
W15	Male	Adult	Killed by another wolverine	2
W17	Male	Subadult	Killed by unknown animal	2
W20	Male	Adult	Unknown natural causes	2
W24	Female	Subadult	Unknown cause	4
W26	Male	Adult	Killed by another wolverine	2
W27	Male	Subadult	Trapper kill	4
W32	Male	Subadult	Killed by another wolverine	2
W34	Female	Adult	Unknown cause	2
W35	Male	Adult	Trapper kill	3

Table 89. Other known mortalities of wolverine within the Northern Wolverine Project study area.

Year	Number of Mortalities
1996	0
1997	9
1998	2
1999	1

Table 90. Radio-transmittered adult female wolverine inhabiting maternal dens or verified producing litters from 1996-1999 (shaded cells are time periods when wolverine was not equipped with a radio-transmitter).

Wolverine	1996	1997	1998	1999
W02	Yes		Yes	
W07	No	No	No	No
W08	?			
W10	Yes	Yes	Yes	
W11	?			
W13		No	Yes	
W18		Yes		
W21		Yes		
W34			No	

Table 91. Reproductive tract conditions for necropsied wolverine.

Specimen No.	Reproductive Tract Condition	Placental Scars	Embryos	Corpora Lutea
W97-01	3 developing embryos		3	2 (1 ovary only)
W97-03	largest, likely has reproduced in past	none evident	0	4
W97-06	thin and flaccid	none evident	0	0
W97-07	large but uncertain of past reproduction	none evident	0	0
W97-11	thin and flaccid	none evident	0	0
W98-01	Small, immature – has not reproduced		0	0
W98-03	Small, non-parous		0	0
W98-05	Parous, scars evident		0	Being processed
W98-05	Non-parous		0	0
W99-01	No scars evident		0	0
W99-09	Corporus albicans present, no placental scars evident		0	0

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6.0 Personal Communications

Malcolm McAdie, Wildlife Veterinarian, Nanaimo, B.C.

7.0 Appendices

Appendix 1. Wolverine capture data form.

NORTHERN WOLVERINE - CAPTURE DATA FORM

WOLVERINE'S NAME: ______________________________

WOLVERINE #: __________ DATE: (dd/mm/yy) _____________

TRAP SITE: ____________ PERSONNEL:__________________

SEX: | male | female | AGE CLASS: | juvenile | yearling | adult |

DRUGGING PROCEDURE:

ESTIMATED WEIGHT: ________________kg

Note: Telazol concentration should be 100 mg/ml

DOSE	DRUG	VOL (ml)	CONC. (mg/ml)	TOTAL (mg)	TIME	INJECTION LOC.	COMMENTS
1	TELAZOL						
2	TELAZOL						
3	TELAZOL						

BEHAVIOURAL AND PHYSIOLOGICAL RECORD:

FIRST EFFECT TIME |___:___| INDUCTION TIME |___:____| FIRST ACTIVITY TIME |____:____|

TIME	BEHAVIOUR	RESP RATE (BPM)	HEART (BPM)	RECTAL TEMP	CRT
____: ____|	___ ______ _____ ____ ____ ______	___________	____|	_____	____ _____ __|
____: ____|	___ ______ _____ ____ ____ ______	___________	____|	_____	____ _____ __|

____: ____| ___ ______ _____ ____ ____ ______ -___________ ____| _____ ____ _____ __|
__ _ __ | - |
-
-
|

____: ____| ___ ______ _____ ____ ____ ______ -__________ ____| _____ ____ _____ __|
__ _ __ | - |
-
-
|

____: ____| ___ ______ _____ ____ ____ ______ -__________ ____| _____ ____ _____ __|
__ _ __ | - |
-
-
|

RADIO COLLAR:

FREQUENCY: _________ SERIAL NO: _________

COLLAR LENGTH:__________

VERIFY COLLAR INSERT USED _____________

VERIFY COLLAR TRANSMITTING (REMOVE MAGNET)______________

EAR TAGS:

LEFT EAR TAG #______ COLOUR _________

RIGHT EAR TAG # ______ COLOUR ________

TRAPPING:

TYPE OF CAPTURE: | barrel | cabin | havahart | leghold

BAIT USED: | fish | meat | other______________

PHYSICAL CHARACTERISTICS AND CONDITION:

BODY WEIGHT __________kg

TOTAL LENGTH __________cm

TAIL LENGTH __________cm

SHOULDER HT __________cm

HIND FOOT: L_____ W_____cm

FRONT FOOT: L_____ W_____cm

TOOTH WEAR: | min | mod | heavy |

NECK GIRTH __________cm

HEART GIRTH __________cm

INCISOR TO GUM LINE:

TOP ___________cm BOTTOM _________cm

EVIDENCE OF YOUNG: | rubbed| normal |

EXTERNAL PARASITES: | yes | no |

PHOTOS: ROLL # _____ PHOTO # ______________________

BIOLOGICAL SAMPLES:

TOOTH EXTRACTED (**ULPM1 preferred**):____________________

HAIR SAMPLE COLLECTION #: __________________________________

EXTERNAL PARASITE SAMPLE COLLECTION #: _____________________

FAECES SAMPLE COLLECTION #:_________________________________

BLOOD SAMPLES: #____________________________

COMMENTS (physical examination - colouration, pelage condition, scars, dentition etc.)

Appendix 2. Wolverine aerial location form.

NORTHERN WOLVERINE - AERIAL TELEMETRY FORM

Form AT _____

DATE (dd/mm/yy) _________________

OBSERVER: _________________

SPECIES: _________________

FREQUENCY: _____________

ANIMAL NUMBER: ________

TIME OF LOCATION: _____________

PILOT: ________________________

NAVIGATOR: _____________________

COORDINATES (specify NAD 27 or 84)

LAT: ____________________

LONG: __________________

EASTING: _______________

NORTHING: _____________

HABITAT : _____________________________________ CANOPY COVER (%): _______

{BEC ZONE / VAR: ____________________FOREST COVER LABEL:_______________________

{INFERRED BEU:__________ SS:_____________ ELEV: ______________________(specify ft/m)}

ASPECT: N NE E SE S SW W NW

MESO SLOPE: FLAT/SHALLOW/MODERATE/STEEP

MACRO POSITION: APEX/FACE/UPPER/MIDDLE/LOWER/VALLEY FLOOR/FLOOD PLAIN

PHOTOS: ROLL #______ PHOTO # ____________

COMMENTS: ____

DIAGRAM:

OFFICE____

MAP SHEET NOs: 1:50,000:___________________ 1:20,000:____________________________

AIRPHOTO NO: ___________________

FLIGHT LN: _______

PLOTTED COORDINATES: EASTING______________ /NORTHING____________________

DATUM FOR PLOTTED COORDINATES: (specify NAD 2 7 or 84)

COMMENTS(i.e. accuracy of GPS loc. w.r.t. plotted loc., confidence, whether photos are needed for verification etc.):

____

____

____

____

____

____

____

____

____

Appendix 3. Habitat description form.

NORTHERN WOLVERINE - HABITAT DESCRIPTION FORM

FORM H: ________

SURVEYORS: ______________________ **DATE OF INSPECTION(dd/mm/yy):__________**

ANIMAL I.D.: ______________________ **DATE OF USE(dd/mm/yy): __________**

MAP SHEET: ______________________

UTM: EASTING ________________ **NORTHING ____________________**

AIR PHOTO NUMBER:_____________ **SUBZONE/VARIANT: _______________**

SITE SERIES: _____________________ **SERAL STAGE: _____________**

ELEVATION (m): ____________ **ASPECT: ____________** **SLOPE: _____________**

SNOW DEPTH ______________ **SINKING DEPTH: ____________**

SITE DESCRIPTION

SITE POSITION MACRO

1. APEX
2. FACE
3. UPPER SLOPE
4. MIDDLE SLOPE
5. LOWER SLOPE
6. VALLEY FLOOR
7. FLOODPLAIN

SITE POSITION MESO

1. CREST
2. UPPER SLOPE
3. MIDDLE SLOPE
4. LOWER SLOPE
5. TOE
6. DEPRESSION
7. LEVEL

MICROTOPOGRAPHY

1. SMOOTH
2. MICROMOUNDED
3. SLIGHTLY MOUNDED
4. MODERATELY MOUNDED
5. STRONGLY MOUNDED
6. SEVERELY MOUNDED
7. ULTRAMOUNDED

VEGETATION (% cover)

COVER CLASS	A0	A1	A2	A3	A	B1	B2	B	C	D
CONIFERS										
DECIDUOUS										
SHRUBS										
HERBS										
MOSS										

NON-VEGETATED [ ]

VEGETATION STRATA DESCRIPTIONS

A0 - VETERANS
A1 - DOMINANT TREES
A2 - MAIN TREE CANOPY
A3 - TREES
A - TOTAL TREES

B1 - TALL SHRUB (2-10m)
B2 - LOW SHRUB (0-2m)
B - TOTAL SHRUBS

C - HERBS

D - MOSS

SCATS COLLECTED: _______ **PHOTOS: ROLL #______** **PICTURE #s ___________**

CIRCLE THOSE WHICH APPLY:

VERIFICATION	**USE**	**FOOD SPECIES**
1. TRACKS	**1. SCAVENGE**	**1. ______________**
2. SCAT	**2. PREDATION**	**2. ______________**
3. HAIR	**3. DEN**	**3. ______________**
4. AERIAL TELEMETRY	**4. MATING**	**4. ______________**
5. GROUND TELEMETRY	**5. TRAVEL**	**5. ______________**
6. VISUAL	**6. MARKING**	
	7. UNKNOWN	
	8. OTHER ____________	

DIAGRAM:

COMMENTS:

Appendix 4. Den site description form.

NORTHERN WOLVERINE - DEN SITE INSPECTION FORM

DEN FORM D__________

HABITAT FORM H__________

DATE (dd/mm/yy): ___________ SURVEYORS: ______________________

DATE OF USE: ______________ WOLVERINE I.D. ______ FREQUENCY: __________________

TOTAL NUMBER OF ASSOCIATED DENS ___________

ASSOCIATED DEN FORMS D _______________ TO D___________________

UTM: N: ________________ E: ________________

ELEVATION (m): ________ ASPECT: __________ SLOPE: __________

DEN TYPE	DEN OPENING ASPECT (Degrees)	MEASUREMENT (cm): WIDTH	HEIGHT
1. STUMP	1. ________________	_________	________
2. LOG	2. ________________	_________	________
3. ROCK	3. ________________	_________	________
4. OTHER	4. ________________	_________	________

DIAMETER OF DEN TREE/STUMP: ______ cm SPECIES: ____________

HEIGHT OF DEN TREE: ______ meters

DIAMETER OF DEN LOG ______ cm SPECIES:____________

LENGTH OF DEN LOG: ________ cm

SCAT COLLECTED?: ______ HAIR COLLECTED?: ______ KITS PRESENT?: ____________

PHOTOS: ROLL# _____ PHOTO # ________

CIRCLE THOSE WHICH APPLY:

VERIFICATION	USE
1. TRACKS	1. SCAVENGE
2. SCAT	2. PREDATION
3. HAIR	3. DEN
4. AERIAL TELEMETRY	4. MATING
5. GROUND TELEMETRY	5. TRAVEL
6. VISUAL	6. MARKING
	7. UNKNOWN
	8. OTHER ________________

DIAGRAM OF DEN (INDICATE NORTH):

COMMENTS: