Inventory Methods for Medium-sized Territorial Carnivores:

Coyote, Red Fox, Lynx, Bobcat, Wolverine, Fisher & Badger

Standards for Components of British Columbia's Biodiversity No. 25

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Preface

This manual presents standard methods for inventory of Medium-sized Territorial Carnivores in British Columbia at three levels of inventory intensity: presence/not detected (possible), relative abundance, and absolute abundance. The manual was compiled by the Elements Working Group of the Terrestrial Ecosystems Task Force, under the auspices of the Resources Inventory Committee (RIC). The objectives of the working group are to develop inventory methods that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species component of biodiversity.

This manual is one of the Standards for Components of British Columbia's Biodiversity (CBCB) series which present standard protocols designed specifically for group of species with similar inventory requirements. The series includes an introductory manual (*Species Inventory Fundamentals No. 1*) which describes the history and objectives of RIC, and outlines the general process of conducting a species inventory according to RIC standards, including selection of inventory intensity, sampling design, sampling techniques, and statistical analysis. The *Species Inventory Fundamentals* manual provides important background information and should be thoroughly reviewed before commencing with a RIC species inventory. RIC standards are also available for vertebrate taxonomy (No. 2), animal capture and handling (No. 3), and radio-telemetry (No. 5). Field personnel should be thoroughly familiar with these standards before engaging in inventories which involve any of these activities.

Standard data forms are required for all RIC species inventory. Survey-specific data forms accompany most manuals while general wildlife inventory forms are available in *Species Inventory Fundamentals No. 1 [Forms]* (previously referred to as the Dataform Appendix). This is important to ensure compatibility with provincial data systems, as all information must eventually be included in the Species Inventory Datasystem (SPI). For more information about SPI and data forms, visit the Species Inventory Homepage at: http://www.env.gov.bc.ca/wld/spi/

It is recognized that development of standard methods is necessarily an ongoing process. The CBCB manuals are expected to evolve and improve very quickly over their initial years of use. Field testing is a vital component of this process and feedback is essential. Comments and suggestions can be forwarded to the Elements Working Group by contacting:

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report “The Future of our Forests”.

For further information about the Resources Inventory Committee and its various Task Forces, please access the Resources Inventory Committee Website at: http://www.for.gov.bc.ca/ric.

Terrestrial Ecosystems Task Force

All decisions regarding protocols and standards are the responsibility of the Resources Inventory Committee. The current version of this manual was the result of the hard work and expertise of Vivian Banci with valuable comments from Nancy Newhouse (Sylvan Consulting Ltd.), Trevor Kinley (Sylvan Consulting Ltd.), Richard Weir (Artemis Wildlife Consultants), John Boulanger (Integrated Ecological Research), Mike Badry (Ministry of Environment, Lands & Parks), Eric Lofroth (Ministry of Environment, Lands & Parks) and Dr. Charles Krebs (University of British Columbia).

Some of the background information and protocols presented in this document are based on Version 1.1 of this manual and the unpublished government report, *Standardized Methodologies for the Inventory of Biodiversity in British Columbia: Techniques for Medium-sized Territorial Carnivores*, prepared by David F. Hatler and C. Lisa Mahon with editorial assistance by Tom Ethier, Ann Eriksson and Leah Westereng.

This manual was edited to its final version by James Quayle and Leah Westereng.

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1. INTRODUCTION

There are 20 terrestrial species of territorial, mammalian carnivores in British Columbia (Resources Inventory Committee 1998). Although an ecologically diverse group, the carnivores described in this manual share some important characteristics from an inventory perspective. Most are stealthy and secretive, occur at low densities, and range over wide areas in comparison to herbivores of equivalent body sizes. Their secretive nature has not only helped to capture the public interest but also made this group one of the most difficult, and expensive, to study and to inventory. Further, extensive declines in the numbers and distribution of species such as lynx (*Lynx canadensis*), fisher (*Martes pennanti)* and wolverine (*Gulo gulo)* in adjacent jurisdictions of the conterminous United States have increased the conservation importance of these species on the Canadian side of the border (Ruggiero *et al.* 1994).

This report outlines protocols for inventory methods which are potentially applicable to a group of seven, medium-sized territorial carnivores. Included are two canids, the coyote (*Canis latrans*) and the red fox (*Vulpes vulpes*); two felids, lynx and bobcat (*Lynx rufus*); and three mustelids, wolverine, fisher, and the badger (*Taxidea taxus*). All but the badger are designated as furbearers and are trapped and, to a lesser extent, hunted. This group of animals will be collectively referred to as “medium-sized carnivores” or the “inventory group” for the remainder of this manual.

1.1 Biological Considerations

Assessing the presence or abundance of animals requires an understanding of the spatial and temporal patterns in which they occur. These vary among the species within the inventory group. Canids commonly occur in cohesive family groups containing adults of both sexes. In contrast, mustelids tend to be solitary throughout the year although family groups of females and young will form between parturition and dispersal. Sections 1.1.1 through 1.1.4 provide general discussion of the range of variation in life history across the group of medium-sized carnivores with special relevance to the selection of inventory methods. In Section 2, the particular characteristics of each species are outlined in individual accounts.

1.1.1 Broad Distribution Patterns

Although badgers and bobcats have distributions restricted to the southern portion of British Columbia, the other medium-sized carnivores tend to be widely distributed throughout the province, often utilizing differing suites of habitats in different areas. As abundance is a function of varying ecological conditions, any inventory program must be tailored to the ecoprovince (Demarchi 1993) and biogeoclimatic zone in which the species occurs.

The geographic ranges outlined in the species accounts are primarily from Stevens and Lofts (1988). Information on distribution of badgers was modified slightly based on Rahme and Harestad (1991). Broad limits of distribution are reported, but data for most of the species are not sufficient to identify distribution gaps or make distinctions between regular and occasional occurrences.

1.1.2 Local Distribution Patterns

Carnivores exist in relatively low densities, almost always reflecting the abundance and availability of local prey. This has implications for inventory as the lower the density of animals, the larger the area that must be sampled to attain a particular level of precision. It is common among territorial carnivores for populations to consist of both "residents" that own territories and "transients" that do not (Hawley and Newby 1957; Hatler 1976; Magoun 1985). The latter, mostly dispersing young and some adults that have not established or have abandoned territories, may comprise a substantially higher proportion than the former in some cases. The highest carnivore densities occur temporarily, when transients converge on a concentrated food source. It is important that such concentrations not be construed as representative of the larger areas in which they lie.

The daily activity of the medium carnivores varies, depending on the activity and availability of prey. In general, activity times will not influence choice of inventory method. Weather, however, is an important influence on behaviour and will influence both the choice and application of inventory methods.

1.1.3 Home Ranges and Movements

The medium-sized carnivores do not make predictable, large-scale (population level), annual movements between distinct seasonal ranges, and are not concentrated in any particular habitat during any particular season. Rather, as these animals are territorial, individuals tend to spread out over the available habitat, occupying essentially separate, defended home ranges more or less throughout the year. Differences, however, do occur, even within the same species. Home ranges of residents may overlap slightly or extensively, depending on season and behavioural characteristics of the population. Portions of home ranges may be used more in some seasons than in others, and all or portions of home ranges may be abandoned completely in response to changes in prey abundance or availability (e.g., see Ward and Krebs 1985; Banci 1987).

1.1.4 Sign Characteristics

Since carnivores are difficult to observe directly in any consistent and predictable fashion, it is common to attempt to monitor abundance or frequency of local use by counting incidences of "sign", such as tracks, scats, or dens. For such use, the sign must be identifiable to species and relatively easy to locate. There is some potential for confusion of tracks and considerable potential for confusion of scats between certain sympatric carnivore species. These are discussed in the individual species accounts in section 2 (see Murie 1954, Halfpenny and Biesiot 1986, Zielinski and Kucera 1995). The ability to accurately recognize and identify the tracks and sign of this group of carnivores is a specialized expertise and should only be undertaken by trained personnel as the potential for errors and erroneous interpretation is great.

2. INVENTORY GROUP

2.1 Coyote, *Canis latrans* (M-CALA)

This account has been synthesized from Bekoff (1977), Bekoff (1982), Voigt and Berg (1987), and Stevens and Lofts (1988).

General Ecology

The coyote is a highly generalized and adaptable species, occurring widely throughout British Columbia. Coyotes are omnivores and will use some vegetable matter (especially fruits) and carrion opportunistically. They prey on livestock and domestic animals and are a frequent culprit in problem wildlife issues, in both rural and urban areas.

Although a pair bond between sexes may develop months before mating, the female is monestrus, going into heat sometime between January and March. The young are born about eight weeks later, usually in excavated dens and often on south-facing slopes, although other sites (hollow logs, caves) and exposures have also been used. The reproductive potential of coyotes is high and populations can withstand high mortality rates. Most documented mortalities are human-caused, although the impact of diseases such as distemper and mange can be significant.

Coyote populations consist of mated pairs, family groups (both adults and young), solitary adults of both sexes, and dispersing young. The frequencies with which these social groupings occur varies among different places and times, but the largest groups are usually observed during winter. Family groups, which include the male, remain together for 6-9 months until, and sometimes, through the first winter. The period of highest activity is usually in the evening, starting at about dusk, but daytime activity is common in some areas in some seasons.

Status

The coyote has dual status as small game and furbearer in B.C., with long hunting seasons and large bag limits throughout its provincial range. It is an important species in local ecosystems, but attracts the attention of managers most often in the context of problem wildlife complaints. It is not the subject of any special management concern (i.e., is not included on either the provincial red or blue lists). Around 1000 are trapped per year.

Distribution and Habitat Use

Coyote range consists of virtually all of the province except the coastal islands and the mainland coast north of Howe Sound. All of the ecoprovinces and biogeoclimatic zones are represented in this distribution although, by implication, the lowest level of occurrence is in the wetter, thicker habitats of the Coast and Mountains and Georgia Depression ecoprovinces (Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones).

Coyotes use almost all types of habitats where prey are available, including heavily urbanized areas. Their distribution to the north is limited by snow and arctic conditions. They are intolerant of and will kill foxes, and they compete with all forest carnivores for carrion and other prey, including the larger predators such as wolves (*Canis lupus*) and cougars (*Puma concolor*).

Home Ranges and Movements

Coyotes usually move continuously in search of food, within defined territories, or more or less randomly for those individuals lacking territories. However, a concentrated source of food, such as a large carcass, may hold many individuals in a small area for a considerable period. Geographic variations in home range, attributed to different ecological conditions, have resulted in a broad spectrum of reported home range sizes, from 4-5 km^2 to 55-143 km^2, although a typical range is from 4 to 12 km^2.

Sign Characteristics

Coyote scats may be difficult to distinguish from scats of other carnivores of the same size, including lynx, bobcat, and badger, especially when they are eating the same prey. The tracks of small coyotes can be confused with those of foxes, and also with those of bobcats in some tracking conditions.

2.2 Red Fox, *Vulpes vulpes* (M-VUVU)

This account has been synthesized from Samuel and Nelson (1982), Voigt (1987), and Stevens and Lofts (1988).

General Ecology

The distribution of the red fox, although extensive, is less than, and appears to be restricted by, coyotes. Foxes are generalists, preying on a large variety of vertebrate prey, fruits, and carrion. Their diet overlaps greatly with coyotes where they occur in sympatry, but larger prey species, such as deer (*Odocoileus spp.*), are not available to foxes except as carrion. The reproductive biology of the red fox is similar to that of the coyote. They are monestrus, mating in mid-to late winter, and pups are born about seven weeks later in early spring. As with the coyote, human causes have been the most regularly documented sources of mortality, but serious incidences of mange, distemper and rabies are also known.

Red fox populations consist of mated pairs, family groups (both adults and young), solitary adults of both sexes, and dispersing young, with the proportions of each varying seasonally and probably locally. Dispersal of young may contribute to unrepresentatively high densities of foxes in some areas during late fall through early winter.

Many small rodent populations exhibit three to four year cyclic populations, which may be reflected in the fluctuation of red fox populations where cyclic rodents are a principle prey. These cyclical changes in fox numbers complicate inventory efforts.

Status

The red fox is managed primarily as a furbearer in British Columbia. Although it is also listed as a small game species, there are currently no open seasons for red fox in any Ministry of Environment region. The red fox is neither red nor blue-listed in the province. Around 300 foxes are trapped annually.

Distribution and Habitat

Red foxes can survive in a wide variety of habitats, ranging from arctic tundra to temperate deserts. As with coyotes, their distribution is a function of the distribution and availability of prey.

The geographic distribution of the red fox in the province coincides with that of the coyote, but is slightly more restricted in coastal areas and is probably more extensive to the north. Within a biogeoclimatic zone, habitat selection is more restricted than is that of the coyote, with red foxes preferring (or requiring) habitats with both openings for hunting and cover for denning. In the northern half of the province, foxes occur in subalpine and alpine tundra habitats more frequently and in greater abundance than do coyotes, and are more commonly detected in those habitats than in adjacent forested lowlands (D. Hatler, pers. obs.).

Home Ranges and Movements

In Canada, home range sizes from 0.9 to 2.0 km^2 have been reported. Denning pairs are territorial and remain in a relatively small local area throughout the denning season. Although red foxes can dig their own dens, they will often use the abandoned dens of other species, including ground squirrels (*Spermophilus* spp.), badgers, and wolves. A den may be repeatedly used for many generations and may become quite conspicuous. Den searches have been used to census populations in open areas.

Sign characteristics

Tracks of foxes may be confused with those of small coyotes or bobcats in areas where both occur. Dens do not necessarily indicate foxes are present. The presence of a natal den can be confirmed by the presence of foxes or sign of activity including extensive prey remains and other sign (V. Banci pers. obs.). Individual foxes may investigate or use dens and leave sign behind but such sign is not as extensive as at natal dens (V. Banci pers. obs.). Fox scats are generally distinguishable from other adult medium-sized carnivores, except fisher, by their size (cord diameter less than 15 mm).

2.3 Lynx, *Lynx canadensis* (M-LYCA)

This account has been synthesized from Hatler (1988) and Koehler and Aubry (1994).

General Ecology

The lynx inhabits the boreal forest. It is a prey specialist tied into a “boom and bust” 10 year cycle with the snowshoe hare (*Lepus americanus*). Most aspects of life history, population dynamics, and management of lynx are best expressed and considered in relation to patterns and trends of hare abundance. In Alaska and northern and central Canada, hare population densities can change 2-200 fold within a five year period. In a response which lags several years behind the hares, lynx populations undergo dramatic fluctuations, from near extinction to densities of 10-20 lynx per 100 km^2 during population peaks. In these times of hare decline, the lynx enters a period of relative stress, potentially manifested by reduced physical condition, increased activity and movements, increased home range size or even abandonment of home range, long distance dispersal, and local “irruptions”. At the southern limits of their distribution, hares do not undergo dramatic cycles and the oscillations in the lynx population cycle are dampened, if they occur at all. A current research study involving radio-collared lynx is underway in the East Kootenay (C. Apps, Ministry of Environment, Cranbrook).

Although lynx are considered solitary, groups, such as a female with kittens, two females with kittens, or mated pairs during the mating season, occur. Most lynx occur as single animals year-round, especially when hare populations are low. Lynx are typically nocturnal.

Status

The lynx is managed as big game, and as a furbearer in British Columbia. It is considered a "Class 2" furbearer ("not present on most registered traplines in manageable numbers, and vulnerable to overharvest"), but it is not on either the red or blue lists in the province. The lynx is listed on Appendix II of the Convention of the International Trade of Endangered Species (CITES), due to pelts being indistinguishable from those of endangered cat species from other continents ("look-alike" species). Lynx harvests during the population high can exceed 1000 animals while 100-200 are trapped during the population low.

Distribution and Habitat Use

The lynx is widely distributed in British Columbia, with the greatest densities occurring in the boreal forest habitats of the northeast, and possibly in the dry forests of the central and southern interior. Lynx are absent from the western (coastal) portions of the province, particularly the area west of the height-of-land in the Coast and Mountains and Georgia Depression ecoprovinces (Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones), but all other ecoprovinces and zones are represented in their broad range. The range of lynx in the province corresponds closely with that of coyote and fox, and is sympatric with bobcat over all of the bobcat's provincial range except in the southern portion of the Coast and Mountains Ecoprovince.

Lynx typically occur in continuous forest communities of varying stand ages. Lynx habitat consists of two structurally different forest types at the opposite end of the age gradient. They require early successional forests that contain high numbers of prey for foraging and late-successional forests that contain cover for kittens and for denning. Intermediate successional stages may serve as travel cover, functioning primarily to provide connectivity within a landscape.

Home Ranges and Movements

Reported home range sizes vary widely (8-783 km^2). Home ranges in the southern part of British Columbia are likely similar to those documented for Washington and Montana, in the range of 16-20 km^2. Lynx will maintain home ranges for several years, if prey are available but ranges may be abandoned during hare lows. Home ranges in southern areas are likely more stable, due to the dampened population cycle. Individual lynx move little when snowshoe hares are locally abundant and available, and may move extensively when hares are low or absent. Extensive movements may involve residents with large territories or transients.

Sign Characteristics

The large, saucer-shaped tracks of lynx may be confused with those of larger carnivores (cougar, wolf) or wolverines in some conditions, but are usually distinct and can be confirmed by a trained observer. Scats usually contain snowshoe hare remains and tend to be segmented, but there may be overlap in features with those of other similar-sized species (especially bobcat but also coyote and wolverine). Lynx may bury their scats.

2.4 Bobcat, *Lynx rufus* (M-LYRU)

This account has been synthesized from McCord and Cardoza (1982), Rolley (1987) and Stevens and Lofts (1988). Information on bobcats in British Columbia is from Apps (1996), Kinley (1992) and T. Kinley (pers. comm. 1998).

General Ecology

The bobcat is the most widely occurring felid in North America. However, in British Columbia, it occurs only in the southern portion of the province as, unlike the lynx, it lacks adaptations for coping with deep snow. Bobcats are specialized predators, with leporids (especially cottontail rabbits, *Sylvilagus spp.*) dominating in most food studies. However, vertebrate prey can range from cricetids to small deer. Bobcats from the East Kootenay consumed red squirrels (*Tamiasciurus hudsonicus*), ungulates and microtines more frequently than rabbits (Apps 1996).

Mating takes place in February or March in most areas, and the young are born in the spring. Dens are not as conspicuous as those of canids, often occurring in rocky terrain, caves or natural cavities in rock piles. Mortalities due to human causes and food failures have been documented, but epizootics appear to be rare.

Bobcats are typically solitary, except for maternal groups and mated pairs. Consequently, most observations will be of single animals. However, more than one individual of the same sex and age class may occur in the same area. Bobcats are typically nocturnal and crepuscular but can also be active during the day.

Status

The status of the bobcat in British Columbia is similar to that of the lynx. It is managed both as big game and furbearer, the latter in the Class 2 category. It is not on the red or blue list. Local concern for populations has resulted in the establishment of a quota of two animals per year for trappers in the Kootenay Region. As with lynx, the bobcat is listed on Appendix II of CITES, due to the concern over “look-alike” species. Some 100 bobcats are trapped per year.

Distribution and Habitat Use

Bobcats in British Columbia are at the northern limit of their range. Their distribution is restricted to the Central Interior, Southern Interior, and Southern Interior Mountains ecoprovinces with an apparent extension into the southern portion of the Sub-boreal Interior. Within this area, distribution can be spotty and even apparently suitable habitat may not maintain bobcats.

Bobcats do not fare as well in deep snow as lynx. As a result, there can be a elevational separation between the two species where the change in snowfall favours one felid over the other. In the East Kootenay, virtually all winter bobcat activity occurs in the Rocky Mountain Trench and at lower ends of major tributaries, below about 1200 m elevation. Within their distribution, bobcats use a variety of habitats but at least some cover of shrubs or small trees appears to be a required component in all but the most arid habitats.

Home Ranges and Movements

Bobcats in British Columbia occur at lower densities than most of the populations studied in adjacent areas of the United States. Average home ranges of 139 km^2 for males and 56 km^2 for females in the East Kootenay were documented (Apps 1996), likely typical for most or all of bobcat range in the province. As with lynx, the nature and extent of individual movements are related to food availability over most of the year. Activity increases during the mating season.

Bobcats in British Columbia do not appear to be strictly territorial, and may not have exclusive home ranges. In the East Kootenay, home ranges of the same sex overlapped nearly 100% during winter although individuals were separated temporally (Apps 1996). Sharing of home ranges in winter was likely necessary due to the restricted amount of low-snow habitat. During summer, bobcats were more spread out.

Sign Characteristics

Bobcat tracks are distinctive in good tracking conditions, but confusion with those of coyotes and foxes are possible. Scats may be difficult to separate from those of lynx where the two species occur together. Scats may be buried.

2.5 Wolverine, *Gulo gulo* (M-GUGU)

This account has been synthesized from Banci (1994). Information on wolverines in British Columbia is from V. Banci (pers. comm., 1998), J. Krebs (pers. comm. 1999) and E. Lofroth (pers. comm. 1999).

General Ecology

The wolverine is one of the rarest terrestrial mammals in British Columbia. Studies in forested habitat are few. Two projects involving radio-collaring and telemetry are currently in progress, near McKenzie (E. Lofroth, Ministry of Environment, Victoria) and in the East Kootenay (J. Krebs, BC Hydro, Cranbrook), and are providing much needed information on the ecology of wolverine in British Columbia

Within their geographic range wolverines occupy a wide variety of habitats. However, a general trait is remoteness from humans and human development. The attributes of wilderness which wolverines require are not known. They are typically solitary, occur at low densities and use large home ranges relative to carnivores of similar size. Groups consist of mated pairs, for short periods, females with kits, and sometimes siblings. Siblings may travel together for extended periods and recent information indicates that associations between and among wolverine may occur more frequently than originally believed.

Although exceptions do occur and there may be considerable overlap in home ranges within a sex, generally ranges are exclusive for unrelated adults. Ranges of males and females overlap completely. Wolverines are opportunistic scavengers, well adapted to feeding on frozen carrion although individuals can become adept at hunting large ungulates. The presence of ungulates appears to be a key component for the maintenance of wolverine populations. Wolverines will survive if large prey are lacking, although they may not reproduce. Diets include all available prey; snowshoe hare may be particularly important, especially during hare population highs. Burrowing sciurids may be important prey items in some ecosystems.

The reproductive output in wolverine populations is typically low. As with all other mustelids, the implantation of blastocysts is delayed following mating. Wolverines may breed during their first year and 1-4 young may be born when females are two years old although documented wild litter sizes in western North America have not exceeded two kits. Reproduction and kit survival is tied to nutrition.

Status

The wolverine is managed both as big game and a Class 2 furbearer. Harvest by hunters is incidental at only a few animals a year. Trappers harvest 200-300 per year. Wolverine are included on the provincial lists due to typically low densities and low reproductive potential.

There are two recognized subspecies of wolverine in British Columbia.

G. g. vancouverensis is a red-listed subspecies which is limited to Vancouver Island. It is very rare and there have been few recorded occurrences since 1990.

G. g. luscus occurs at very low densities throughout mainland British Columbia. It is on the provincial blue list.

Distribution and Habitat Use

Wolverines occur in all ecoprovinces and all biogeoclimatic zones although they have always been rare in the dry Southern Interior and are absent from the heavily urbanized areas in the south. Their movements are not hampered by geographical barriers but they have shown reluctance to cross major roads and large reservoirs. Wolverine are typically associated with wilderness, areas generally devoid or low in permanent human activity. They are sympatric with all species of the inventory group except badgers. Specific habitat associations do not occur although structural complexity in habitat appears to be required for dens (talus slopes, boulders, caves, natural cavities). Current studies indicate that subalpine habitats are important for denning.

Home Ranges and Movements

North American home ranges of adult wolverines range from less than 100 km^2 for females to over 1000 km^2 for males. This variation is, in part, due to differences in the distribution and availability of food. Localized areas of abundant food, such as ungulate carcasses or salmon, may support higher densities of wolverine, if persistent on a yearly basis. Temporary accumulations of such food can attract a number of individuals, especially transients.

Wolverines can travel extensive distances in their search of food; daily movements of 30-40 km are typical. Movements of females with young are more restricted. Adults of both sexes may make occasional long distance forays outside of their home ranges, apparently not related to dispersal. Immature males typically make extensive long distance movements. Immature females tend to establish ranges close to the natal home range.

Sign Characteristics

Wolverine tracks and gait patterns are unique and can be readily identified by a trained observer, both on the ground and from the air. Confusion with coyote and wolf tracks may occur under poor tracking conditions. Scats are in the size range of coyotes and wolves. Confirmation by an adjacent track or wolverine hair in the scat (due to grooming) is necessary.

2.6 Fisher, *Martes pennanti* (M-MAPE)

This account has been synthesized from Powell (1981), Stevens and Lofts (1988), Banci (1989) and Powell (1994). Information on wolverine in British Columbia is from R. Weir (pers. comm., 1998) and V. Banci (pers. comm. 1998).

General Ecology

Fishers are present only in North America with the highest densities occurring in the east. British Columbia is at the low end of fisher densities. The fisher is a generalist, preying upon or scavenging a variety of mammals and birds, and opportunistically using fruits and nuts across its range. Snowshoe hares are important during population highs. Breeding occurs in late winter, but due to delayed implantation, the young (mean of three per litter) are not born until almost a year later. Although incidences of predation by other carnivores and raptors have been recorded, little is known about natural mortality factors for this species. Incidence of parasites and diseases appears to be low.

Fishers are solitary for most of the year. Temporary higher densities may occasionally occur, when residents and transients converge on a concentrated food source such as carrion or a post-crash, residual patch of snowshoe hares. Fishers and marten (*Martes americana*) may be competitors where they occur together. The larger body size of the fisher gives it an advantage; however, the smaller marten can specialize on voles (*Microtis spp.*) and is not as hampered by deep snow levels. This leads to speculation that marten and fisher are somewhat allotopic, that is ecologically partitioned based on body size within the sympatric portions of their ranges. Following this line of thought, areas supporting many fishers should have few marten and vice-versa.

Status

The fisher is managed as a Class 2 furbearer in the province, and is included on the provincial blue list (considered "vulnerable" or "sensitive"). It is an “identified wildlife species” under the Forest Practices Code. The annual harvest in recent years has been around 300 fishers.

Distribution and Habitat

Two centers of distribution and density occur in British Columbia, within the Cariboo and Peace regions. Fishers likely do not occur in the Alpine Tundra, Bunchgrass, and Ponderosa Pine biogeoclimatic zones. Ephemeral populations or transient individuals seem to exist in the Coastal Western Hemlock, Mountain Hemlock, Spruce-Willow-Birch, and some wetter and colder Interior Cedar-Hemlock and Engelmann Spruce-Subalpine Fir subzones. Fishers probably occur in all other biogeoclimatic zones.

Fishers are usually found in mixed forests with a diversity of tree species and ages. Their habitat needs are inconsistent throughout their range. In British Columbia fishers do not necessarily require closed canopy habitats, although they do require overhead cover and some components of late-successional forests. Structure at the ground level appears to be an important component of stands, regardless of stand age. There is a strong preference for riparian and riparian-associated habitats. Fishers use a variety of resting sites while natal dens are more restricted. Natal dens tend to be inconspicuous, and occur almost exclusively in the cavities of large, dead trees, usually 7-12 m above the ground.

Home Ranges and Movements

Fisher home ranges vary in size depending on habitat and prey availability. Male home ranges are 19-83 km^2, nearly three times those of females (4-32 km^2). Home ranges are exclusive within sexes although male and female ranges overlap extensively. Males appear to abandon home ranges during the mating season, establishing new boundaries once mating is complete. Fishers appear to be most active during the mating period and in late winter, when food needs are high and supply may be restricted.

Sign Characteristics

Fisher tracks may be confused with those of the more common marten in less than excellent tracking conditions. An important distinguishing characteristics, the toe pads in fisher tracks are distinct in snow while those of marten are more diffuse due to their heavily furred feet. The tracks of large male fishers can usually be distinguished by size. Tracks of male marten and female fisher can be difficult to discriminate as they have similar appearances and overlap in terms of size. Careful scrutiny involving back-tracking is often necessary to achieve a confirmation.

Zielinski and Truex (1995) developed a discriminant function to distinguish tracks of marten and fisher left at track-plates. (These artificial media are used for capturing tracks when snow conditions are poor. They are described later in this manual.). The equation requires measuring dimensions of the track with some accuracy and this method will probably be of little use to investigators in British Columbia. Zielinski and Truex (1995) used only high quality tracks from adult individuals in their discrimination, thus in many cases their results will not be comparable. A good background in tracking both marten and fisher in snow is required to discriminate between tracks left by these two species, although this may not always be possible. The fisher cannot always be distinguished by its scats.

2.7 Badger, *Taxidea taxus* (M-TATA)

This account has been synthesized from Long (1973), Lindzey (1982) and Messick (1987). Information of badgers in British Columbia is from Rahme and Harestad (1991) and N. Newhouse (*in prep*. and pers. comm., 1998).

General Ecology

Of all the species in the inventory group, the badger is the rarest in British Columbia. A current research project involving live-trapping and telemetry (Newhouse in prep.) is in progress in the East Kootenay.

The North American badger is generally associated with mid-continental treeless areas such as prairie, plains, parklands, and cold deserts. It is a specialist hunter, morphologically adapted for digging out burrowing sciurids. It opportunistically uses carrion and a range of other animal prey (insects, lizards, snakes, cricetids, leporids, birds and eggs). Breeding occurs in the summer (July or August) and, after an implantation delay and approximately eight week gestation, one to four young (mean of two) are born the following March or April. Human-caused mortality has been documented for several populations, but little is known about the nature or extent of natural mortality in the species.

Badgers are mostly solitary. The young disperse by fall, so that maternal family groups are present only in summer. Although badgers are largely nocturnal, they are frequently active for brief periods during the day when they may be observed traveling, hunting, or sunning themselves on their mounds.

It is worth noting that discussion of the European badger (*Meles meles*) in the literature may not necessarily be relevant to its North American namesake. Like *T. taxus, M. meles* also has conspicuous dens and fossorial habits; however, it also tends to be more social rather than solitary and is largely dependent upon earthworms for prey rather than vertebrates. Inventory techniques developed for the European badger should generally not be used in North America.

Status

The badger is a protected species in British Columbia, and is included on the provincial red list.

Distribution and Habitat Use

The distribution of the badger in British Columbia is the most restricted among the species in this inventory group, with documented occurrence only in portions of the Southern Interior, Southern Interior Mountains, and Central Interior ecoprovinces. Within this broad range, it is concentrated in grassland and open forest communities, particularly the Interior Douglas Fir and Bunchgrass Zones. In the East Kootenay, badgers have been documented from valley bottoms to mountain tops including the Ponderosa Pine, Interior Douglas-Fir, Montane Spruce, Interior Cedar - Hemlock, Engelmann Spruce - Subalpine Fir, and Alpine Tundra biogeoclimatic zones (Newhouse, *in prep.*).

Because the badger is red-listed with a poorly documented distribution in British Columbia, an effort is being made to gather information on badger sightings. The approximate location and date of any recent sightings should be reported to a Wildlife Branch, Ministry of Environment office.

Home Ranges and Movements

A dispersed prey base (primarily Columbian ground squirrels (*Spermophilus columbianus*) and northern pocket gophers (*Thomomys talpoides*)) is probably responsible for the low badger densities throughout most of their range in British Columbia. Individuals may confine themselves to discrete home ranges, with evidence of their activity appearing primarily in the form of new dens and burrows. (The terms burrow and den are used interchangeably in the literature). The activities of badgers which re-use old burrows may not be so obvious; the absence of any recent digging may make it more difficult for an observer to determine if an animal is present.

In the East Kootenay, large home ranges (an average of 42 km^2 for females and 399 km^2 for males) have been documented. Badgers are highly individualistic in their seasonal activity patterns. Many remain fairly active during winter when the fresh diggings and tracks can be quite visible. However, most badgers also enter a state of underground inactivity for days, weeks or months at some time between December and March.

Sign Characteristics

Badgers are often below ground, and leave much of their sign (including a proportion of fecal deposits) in underground burrows. The burrows (or dens) themselves constitute the most conspicuous advertisement of badger occurrence.

3. PROTOCOLS

Species within this inventory group are not readily visible and indirect indications of their presence are typically used in inventory. Such indications, or sign, are suitable for determining presence, and, in some cases, may also be used as indices of relative density. If the relationship between the abundance of sign and abundance of animals is known, sign may also be used as an index of absolute density.

Large differences in distribution, behaviour, movements and home ranges make it difficult to generalize across species. However, one commonality that is consistent with most medium-sized carnivores is that they are difficult to census. Thus, the first question that must be asked is whether it is necessary or even possible to conduct field inventory of a particular species, particularly if some measure of abundance is required. To illustrate some complexities, although red fox are abundant and would appear to be an obvious candidate for inventory, they are subject to large cyclic fluctuations throughout most of their range. Inventory efforts would need to be extensive as meaningful results would have to be gathered over more than one cycle (three to four years). An even more challenging situation exists for lynx which are also subject to population cycling, in conjunction with a secretive nature and nocturnal habits. Inventory of lynx would likely be most successful if directed to the southern part of the range, where densities are lower, and cyclic fluctuations are dampened or absent.

For relatively rare species of restricted distribution, such as bobcats, a great deal of effort is necessary to answer even questions of presence. Questions about relative and absolute abundance require much more intensive effort. If the decision to capture and collar animals is made, studies must be designed to maximize information gained and avoid the need for collaring animals in future inventories. The value and necessity of the information gained must be weighed against both the financial expense and the potential cost in terms of stress inflicted on study animals. Biologists should not be discouraged by the complications of studying medium-sized carnivores, but they should strongly consider which objectives are realistic given the inherent limitations of censusing such secretive, mobile, and generally low density animals.

There have been few attempts to compare methods, or to compare census results against "known" populations, or even against each other. The recommended methods in this manual (Table 1) are based on current information and on the opinion of species specialists who considered logistics, accuracy, precision and applicability. Recommendations may change with time as more information is collected.

3.1 Survey Standards

The following are guidelines for conducting inventories of medium-sized carnivores in the province. Adherence to these guidelines will permit the collection of reliable data that should satisfy individual and corporate inventory needs, as well as contribute to biodiversity monitoring at local, regional, and provincial scales.

3.1.1 Personnel

Experienced personnel are essential during snow tracking and bait/scent station surveys due to the difficulty associated with recognizing and identifying tracks given a variety of tracking conditions. The same surveyors should be present to maintain consistency and accuracy throughout inventory sessions. Trained personnel are also required for hair identification and specialized labs are needed for genetic analyses.

During inventory surveys involving capture and radio-marking, biologists must be well trained in radio-telemetry procedures, handling of firearms, emergency first-aid, handling of potentially dangerous wildlife, care of immobilized animals and must be able to accurately estimate the weight of animals to be drugged. Biologists should consult the manuals *Wildlife Radio-telemetry* (*No. 5)* and *Live Animal Capture and Handling of Wild Mammals, Birds, Amphibians and Reptiles* (*No. 3*). Personnel immobilizing and handling animals are required to have completed a certified course on immobilization techniques.

3.1.2 Habitat Data Standards

Effective surveys should be stratified by habitat whenever possible. The type and amount of habitat data collected depends on the scale of the survey, the nature of the focal species, and the objectives of the inventory. Standards for habitat description in association with species inventory are outlined in the introductory manual, *Species Inventory Fundamentals* (*No.1)*.

3.1.3 Time of Year

Time of year is an important determinant of the success of inventories. In general, the season selected for inventory will be winter, as snow is the best media in which to find and identify tracks, and winter is the best time for trapping. Animals moving during winter are obligated to leave their sign behind and a good tracker will not miss much. However, the presence of snow alone does not guarantee good survey conditions.

Snow-tracking should be conducted 12-24 hours after a fresh snowfall. This will obliterate older tracks and allow animals time to move and make new tracks. Conditions of heavy falling snow and strong winds should be avoided as tracks become obscured quickly. Snow and wind storms can also influence animal movements, as can temperature.

Track media other than snow, such as sooted track plates or sand, are generally not used in winter because snow interferes with track plates, whether they are enclosed or not. In some areas of the province where winds are common or suitable snow conditions are rare, there may be no option but to use these methods. Zielinski and Kucera (1995) recommend that sooted track plates be deployed in the spring.

Bait/scent stations (bait, scent, cameras, hair snares) and live-traps may be used in any season, however trapping experience suggests that winter is also the best time for these methods. In general, canids, mustelids and felids are more apt to investigate bait and scents during winter when food is less available and less diverse. Note, however, that Zielinski and Kucera (1995) found no compelling evidence to suggest spring and fall surveys targeting fisher were less effective than winter surveys. If compelling reasons prohibit winter surveys, surveyors may want to conduct inventories in other seasons.

A major factor complicating inventory efforts in British Columbia is the presence of black (*Ursus americanus*) and grizzly bears (*U. arctos*). Winter work avoids conflicts with bears. Besides safety concerns, for animals (during live-trapping) and researchers, bears can inflict much damage on equipment and may affect the activity of the species of interest.

A specialized technique for determining presence of canids, den searches, are conducted during the denning season, which varies according to species. Searches for canid dens should begin at least two weeks after the young are born. This should be late enough to limit disturbance to whelping females, and early enough that the young will be incapable of traveling with their parents. Den searches, which include surveying for maternal dens and burrows, are the recommended method for determining the presence of badgers.

3.1.4 Sample Units and Survey Design

Medium-sized territorial carnivore surveys follow a sample design hierarchy which is structured similarly to all RIC standards for species inventory. Figure 1 clarifies certain terminology used within this manual (also found in the glossary), and illustrates the appropriate conceptual framework for a scent station survey for red foxes. A survey set up following this design will lend itself well to standard methods and RIC data forms.

This RIC manual follows many of the recommendations of Zielinski and Kucera (1995) including the need to select a Sample Unit appropriate to the species in question to determine presence, as well as abundance. The term “Sample Unit” used by Zielinski and Kucera (1995) is synonymous with the term “Grid Cell” (Figure 1), as used throughout this manual. Within these pages, a Grid Cell is used as the statistical sample unit, allowing investigators to group together stations and transects, in a way which is compatible with the provincial Species Inventory data system (SPI). It will be useful background for a field worker to be aware of the importance of the Grid Cell: RIC data forms and the data system (SPI) will require surveys be documented at the level of the Grid Cell.

Grid Cell sample units should encompass the entire home range of the target species. If surveys are to include both sexes, Grid Cell size should generally correspond to the home range of a female, as these tend to be smaller than those of males. For example, an appropriate Grid Cell for fisher would be a minimum of 25 km^2 whereas for wolverine, an appropriate size would be a minimum of 100 km^2. For surveys which target more than one species, the Grid Cell sample unit should encompass the home range of the species with the smallest home range (Zielinski and Kucera 1995). For relative abundance surveys, sampling is stratified by habitat and sampling effort is appropriate to the target species. For low density populations, sampling effort can be intensive.

Recommendations for Grid Cell dimensions and transect lengths are included in this manual as part of the descriptions for the different methods. As home range size varies depending on ecological conditions, sampling effort may need to be altered depending on where the study occurs. For some species and for some objectives, the necessary effort to achieve an acceptable level of precision may be logistically impossible or beyond the available budget. In those cases, the project should be canceled or modified, rather than conduct a flawed survey.

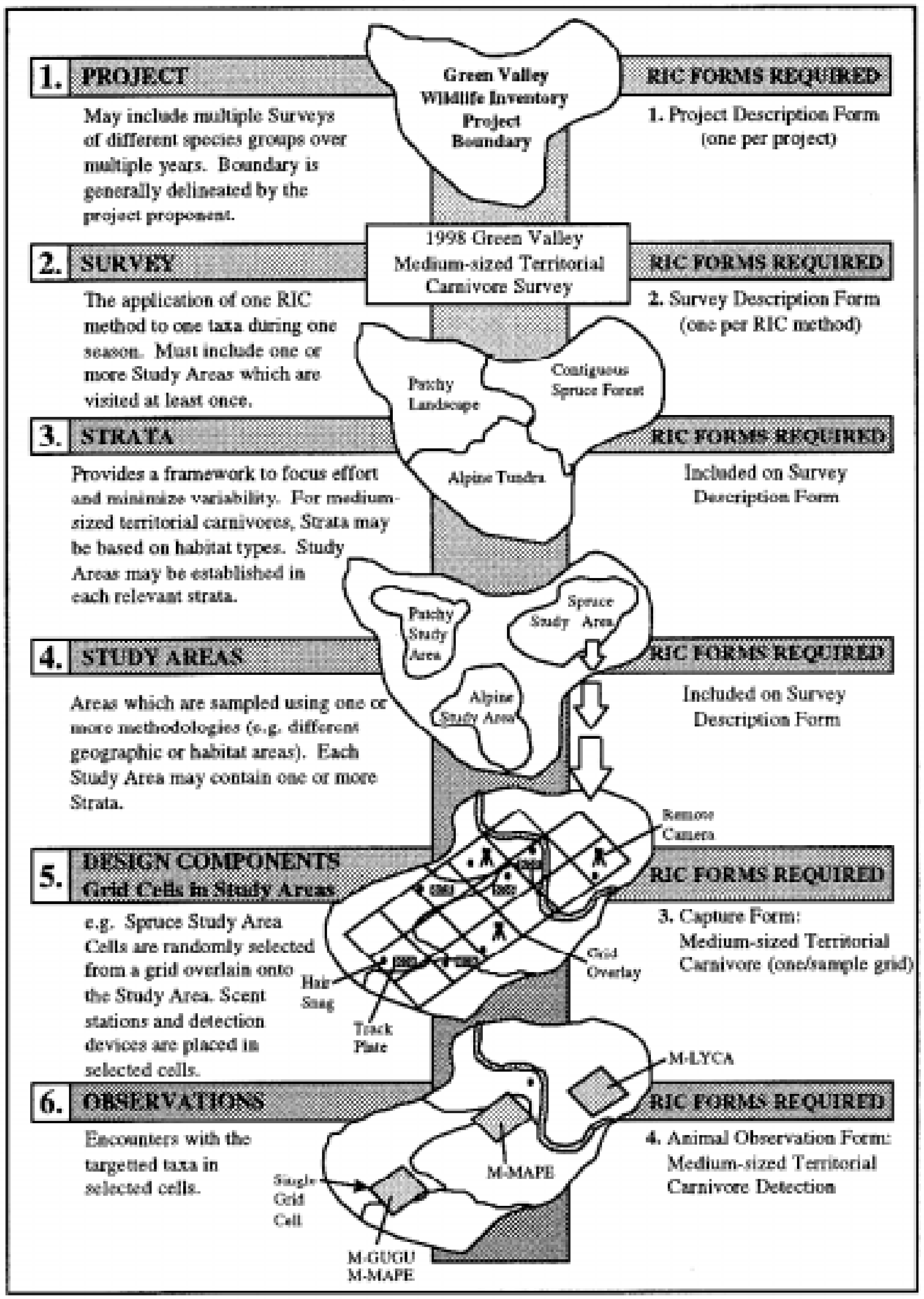

Figure 1. RIC species inventory survey design hierarchy with examples.

3.2 Preliminary Surveys

Preliminary surveys, the first step in any inventory, refer to the gathering of existing information, either in Ministry of Environment data banks or as public knowledge. For rare species which are difficult to document using field procedures, these surveys can be a critical source of information. In some cases, field surveys may not be required if preliminary surveys meet the objectives of the project, especially presence/absence questions.

3.2.1 Harvest Records (Wild Fur Data System)

All species in the inventory group except badgers are designated as fur-bearers in regulation, providing a source of *ad hoc* survey information in the form of fur harvest records. Licensed fur-traders, persons legally able to buy and sell furs, are required to submit monthly tallies. Since 1982, these fur reports have been organized into a computerized system known as the Wild Fur Data System (WFDS). Due to start-up difficulties, returns are considered almost 100% complete only since 1988. The WFDS allows for harvest summaries of the province, or by administrative region, wildlife Management Unit (MU), and trapline.

Obtaining harvest data should be the first course of action in an inventory project of any furbearer. Harvests provide important preliminary information to determining presence/absence and can indicate relative abundance, in conjunction with additional information (see discussion under BC Trapper Questionnaire).

Harvest records of a species on a particular trapline provide a definitive sign of presence, assuming the trapline number has been accurately recorded. However, nil harvests do not necessarily indicate that a species does not occur in an area but may be due to a) an inactive trapline, b) the inability of the trapper to catch the species, c) a conscious decision by the trapper not to set traps for the species, or d) absence of the species.

Harvest data can be a seemingly abundant source of information, and have often been misused as indicators of population status or trend. Biological factors such as the abundance of furbearers and their prey, and socioeconomic factors which affect trapper effort such as pelt price and demand, and external factors such as the weather and access, all influence the size of the annual harvest (Macleod, 1950; Erickson 1982; Todd and Boggess, 1987, Reid 1988). If information is available on trapper effort and on those external factors which affect trapper effort, harvests may be able to provide information on relative abundance, as discussed below.

Office Procedures

- Select a geographic area to be surveyed.
- Obtain relevant maps for survey area (topographic, ecoregion). For trapline level analysis, 1:250,000 scale maps are appropriate.
- Identify registered traplines within the Study Area. Trapline maps are available at Wildlife Branch regional offices. Trapline numbers have the form “TR0718T002”, where ‘TR’ refers to trapline, ‘07’ is the administrative region, ‘18’ is the management unit and ‘T002’ is the number of the trapline.
- Request required data from either the Wildlife Branch Headquarters in Victoria, or the appropriate Region, indicating the species of concern, area (province, management unit or trapline) and years required. Note that the Freedom of Information Act prohibits

attributing harvests to individual registered traplines. If such information is essential for management and conservation, application must be made to the Director of the Wildlife Branch. Alternatively, approval for release of such data may be obtained in writing from the holder(s) of the registered trapline.

- If the area of interest is an ecoprovince, the allocation of traplines within ecoprovince boundaries is available in Appendix A of this manual and in each of the trapper questionnaire reports (Rollins 1989). Harvest data within the Wild Fur Data System is presently not cross-referenced with British Columbia’s ecoregion classification.
- For a presence/not detected assessment, determine whether the species was trapped and in what years. As an absence of data may not necessarily indicate an absence of the species, further investigation is necessary, as discussed under Section 3.2.3, *Questionnaires and Public Appeals.*
- For all other assessments, define the limitations and potential biases of the harvest data obtained.

Sampling Effort

- The amount of effort expended on a preliminary survey depends on the species of interest, the survey objectives and the level of survey intensity.
- Obtaining the required information is relatively quick, once staff has the time to retrieve it from the Wild Fur Data System.
- The time required for analyses of harvest data will depend on the complexity of the data, the number of confounding variables, and the questions being asked.

Personnel

- Depending on the inventory objectives, one person familiar with the biology of the species is required. Additional expertise on survey design, and statistical analyses may be required.

Equipment

- Maps of the Project Area
- Computer and statistical analysis software

3.2.2 Hunter Records

Four species, coyote, wolverine, lynx and bobcat, are also designated as game and can be hunted. Hunting using hounds is an important source of mortality for lynx and bobcat in the Kootenays while few wolverine are taken by hunters. As coyotes are taken by hunters primarily as a problem species, bag limits and seasons tend to be generous.

Reporting is compulsory for:

- any lynx, wolverine and bobcat taken by hunting in all administrative regions of the province.
- any wolverine and fisher taken by trapping in all administrative regions of the province.
- any bobcat and lynx taken by trapping in the Lower Mainland, Kootenays and Okanagan (Regions 2, 4, and 8).

Information which can be provided by the Wildlife Branch (Headquarters and appropriate Region) includes the location, date and sex of the animal killed. For trapped animals, information on effort expended is also collected. Information on coyotes is available from the yearly hunter survey, at the management unit level.

As hunter records are supplementary to trapping records, these should be requested in conjunction with harvest information, as described above.

Office Procedures

- As above
- Hunter records are a supplementary source of data and should be requested at the same time as trapping data.
- Records can be assigned to traplines and combined with trapping data.

3.2.3 BC Annual Trapper Questionnaire

The Annual Trapper Questionnaire provides additional data useful to the interpretation of harvest statistics. However, investigators obtaining these reports need to be aware that the administration of the questionnaire has not been consistent.

The shortcomings of harvest data to estimate the abundance of furbearers was identified by the Fur Management Section in Victoria and a methodology was developed for conducting a mail survey of trappers in British Columbia. This methodology was tested with a pilot group of trappers and in 1989 subsequently adopted. The questionnaire was administered yearly, with small changes in questions, until the 1992/93 trapping season. A sample of 1000 trappers were selected randomly each year and return rates were consistently high, ranging in the 70-80% range after the first year.

The objectives of the questionnaire were:

1. To measure trends of furbearer abundance, as perceived by trappers;
2. To collect trapper impressions of any changes in habitat that may be influencing the number of furbearers;
3. To collect trapper impressions of the abundance of important food sources likely to influence the numbers of furbearers;
4. To measure trapper effort related to trapping; and,
5. To measure catch per unit effort, as an index to abundance.

For each species, questions on the number of traps set for that species, the total number of days spent trapping, and the length of time in between checking traps were used to provide an index to trapper effort. When combined with responses about harvest, a "catch per unit effort" (CPU) index was computed for each species on an ecoprovince basis:

$$\text{CPU} = \frac{\text{Estimated harvest}}{\dfrac{(\text{Estimated traps/ species/ line}) \times (\text{Estimate total days trapped})}{\text{Checking interval}}}$$

The questions designed to measure catch per unit effort were dropped from the trapper survey in 1993/94 due to concerns that replies were inaccurate and results misleading.

Office Procedures

All yearly reports (e.g., Rollins 1992, 1993) for desired years between 1989 and the present are available and can be requested from the Wildlife Branch (Headquarters, Victoria), at the same time that requests for harvest data and hunter records are requested.

3.2.4 Questionnaires and Public Appeals

Where detailed information is required, or for areas smaller than the trapline level, questionnaires and interviews targeted to specific groups can provide important information on animal occurrence and abundance.

Mail questionnaires are generally a practical approach due to low administrative involvement, and the ability to canvass a large area from a central location. However, measures of accuracy and precision are unattainable because the data collected are usually on a nominal scale. Bias is present due to variable response rates and non-response bias (differences between respondents and non-respondents). Those problems can be ameliorated somewhat by pre-survey contacts, use of "user-friendly" format and content, and mail follow-ups (Filion 1978). This was the approach used to develop the BC Annual Trapper Questionnaire.

Mail questionnaires have been utilized to detect or assess populations of red fox (Lemke and Thompson 1960), European badger (Aaris-Sorensen 1987), lynx (Brand and Keith 1979), a combination of coyote, bobcat, gray and red fox (Hatcher and Shaw 1981), and wolverine (Groves 1988). An extensive campaign including posters, radio and newspaper advertisements were used to obtain data on sightings of badgers in the East Kootenays during the current research study (Newhouse, *in prep.*). Trapper mail questionnaires were considered to be a good indicator of wolverine population trends by Hash (1987) who indicated that indices should be regional rather than local, since wolverines travel great distances over short periods and give a false impression of abundance.

The value and importance of traditional ecological knowledge (TEK), that held by the elders of First Nations, has long been recognized in northern Canada. Although efforts by territorial governments to collect such information has been ongoing for years, it is only since the recent tremendous explosion in mineral exploration activity that TEK has gained substantially in prominence. For example, during the public hearings for the BHP Minerals / Diamet Etaki diamond mine in the Northwest Territories, the direction from the federal government appointed panel was that traditional knowledge be given equal weight to scientific knowledge. As yet, TEK has been given little attention by most biologists in British Columbia, but this is beginning to change.

Another source of information is local use knowledge, that held by the current First Nation users of the wildlife resource. This is especially important where there is substantial local use of a species. For example, in some northern communities many wolverine pelts are used locally, resulting in pelts not being sold and as a result, not being documented in provincial harvests. To account for local use, some Wildlife Branch regional offices have conducted “harvest surveys” of First Nations communities. Although TEK and local use information may be more difficult to obtain than surveys of non-First Nations people, the value of this knowledge should not be discounted, especially where other information is absent or where historical information on occurrence, distribution or relative abundance is required.

Office Procedures

- Develop a list of people to include in the survey. Include biologists, foresters, hunters, houndspeople (for lynx and bobcat), guide-outfitters, ranchers, farmers, animal control personnel and trappers. Focus on the portion of the population who are most likely to encounter the target species and to provide positive identification.

For surveys of First Nations people:

- The traditional knowledge held by First Nations people is proprietary and permission from the Chief and Council prior to contacting individuals is required. Even a fairly simple survey can require interpreters. The Aboriginal community may also request that they conduct their own surveys of their people. If investigators wish to embark upon a TEK survey, it is strongly recommended that an experienced professional be employed prior to any inquires of First Nations people.
- Determine if any harvest surveys have been conducted by Regional Wildlife Branch offices. Regional staff may also direct you to staff within the Ministry of Aboriginal Affairs for assistance.

For all other surveys:

- Design a mail-out or interview questionnaire so that respondents provide data on: (1) location, dates, and numbers of animals sighted, and (2) location and details of sign observed.
- If appropriate, use other media such as posters, radio and newspaper ads and television ads.
- Define the limitations and potential biases of the data obtained from these preliminary surveys.
- Consult with a biometrician or quantitative ecologist who is familiar with the analysis of harvest, interview, and mail-out questionnaire data.

Sampling Design

- If the primary objective is to gather information supplementary to main inventory techniques, strict adherence to sampling design is not necessary. However, if this will be the only source of information, a specialist in formulating, administering and analyzing questionnaire results should be consulted.

Sampling Effort

- Sampling effort is a function of the questions being asked, the number of people being interviewed, and the time that is allowed in between follow-up requests. At least two months should be budgeted. A year minimum, including time for consultation, should be allowed for surveys of First Nations people.

Personnel

- One person familiar with the biology of the species, scientific design, and computer statistical analyses is needed for preliminary surveys. If the person is not familiar with statistics or computer modeling, s/he should work closely with a biometrician or quantitative ecologist.

Equipment

- Maps of the Project Area
- Computer and statistical software

3.3 Inventory Surveys

Table 1 outlines the types of field surveys recommended for inventorying medium-sized terrestrial carnivores at various survey intensities. These survey methods have been recommended by wildlife biologists and approved by the Resources Inventory Committee (RIC).

Table 1. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Type	Forms Needed	*Intensity
Snow Tracking	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form- Medium-sized Territorial Carnivore Snow Tracking	• PN • RA •
Detection Stations 1. Bait/Scent 2. Cameras 3. Sooted Plates 4. Hair Snares 5. Scats	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture Form - Medium-sized Territorial Carnivore • Animal Observation Form - Medium-sized Territorial Carnivore Detection	• PN
Den Searches	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form- Medium-sized Territorial Carnivore Den Search	• PN
Capture/ Telemetry	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture Form - Medium-sized Territorial Carnivore • Animal Handling Form - Medium-sized Territorial Carnivore • Animal Observation Form - Medium-sized Territorial Carnivore Location by Radio-telemetry	• AA
DNA - Mark-Recapture	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture Form - Medium-sized Territorial Carnivore • Animal Observation Form - Medium-sized Territorial Carnivore Hair Collection • Include a spreadsheet with Hair DNA Analysis information (example provided)	possible use for AA

PN = presence/not detected (possible); RA = relative abundance; AA = absolute abundance

3.4 Presence/Not Detected (Possible)

Recommended method(s): Snow tracking is the method of choice for surveying at the presence/not detected level of intensity. Bait/scent stations augmented with either remote cameras or hair snares, and tailored to the target species, are recommended for species not readily detected by snow tracking. Appropriate methods for detecting badgers are few. Thus, for this level of inventory, 1) den searches and 2) bait/scent stations are recommended.

In general, any method that detects a species can be used for investigating presence. Snow-tracking is applicable for all of the species in the inventory group, except the badger, throughout most of British Columbia. Snow-tracking may be a more reliable method than bait/scent stations because it does not depend on the animal being attracted by a lure. The latter is a form of trapping and may not reveal the presence of wary or trap-shy animals. However, because of large home ranges and extensive movements, wolverine are best suited to snow tracking at very large bait stations coupled with hair snares and/or cameras. Although locating a fox or coyote maternal den would certainly confirm presence, the first methods of choice should always be snow-tracking, followed by bait/scent stations.

Where a species is extremely rare and confirmation of its presence or absence is critical, bait/scent stations will produce the most unambiguous results, especially if some uncertainty in the identification of tracks is expected due to poor weather or snow conditions. In this case, stations equipped with cameras and / or hair snares are recommended.

The most economical means to survey large areas is to terminate surveys once the target species has been detected, or undetected after a reasonable amount of effort has been expended (Zielinski and Kucera 1995). Failure to detect presence does not necessarily confirm absence. The credibility of data on absence relates to a) expectations based on known, broad geographic ranges and seasonal habitat selection, b) the distinctness of sign in the season and habitat(s) surveyed, and c) the intensity of the search. Multi-year surveys may be required.

3.4.1 Snow-tracking

Winter track count transects have been used to assess the relative abundance of terrestrial furbearers (Penner 1979; Slough and Jessup 1984; Gyug 1988; Thompson *et al.* 1989) and are suitable for determining presence. Transects may be of variable length and number, depending upon the target species, time limitations, and accessibility, and can be surveyed on foot, by snow-machine, truck or, for some species in suitable areas, from the air (airplane or helicopter). Surveying tracks from the air requires considerable expertise.

The accuracy of snow tracking to detect the target species depends, in part, upon climate and animal responses to effects that are not easily measured and beyond the control of the observer. For example, different results will likely be obtained if the "days since last snowfall" are characterized by temperatures averaging -40°C, as compared to -5°C, or if they are windy rather than calm. Both wind and temperature influence animal behavior, and may have additional effects on the capability of the snow to retain track impressions. However, snow tracking, despite its dependence upon conditions that cannot be scheduled or controlled, has the greatest utility for medium-sized carnivores at this sampling level, with the potential to provide data on all species except badger.

If the objective is solely to determine whether the target species occurs in an area, sampling should concentrate on high quality habitats. A general habitat characteristic for this inventory group is that topographic features such as ridges, saddles, valley bottoms and riparian areas are important travel routes. The impact of weather is species dependent. For example, a wolverine may not be affected by a heavy snowfall which may cause a fisher to wait a day or two before moving. Similarly, wolverines appear less likely to curtail their movements in cold temperatures (<-20 °C) which will cause fishers to limit movements. Combinations of snow and fluctuating temperatures may also lead to snow crusting, which may support animals with lower foot area: body weight ratios while making travel difficult for species which fall through the crust. An appropriate sampling design must be developed based on the behaviour of the target species and on knowledge of conditions within the Study Area. A degree of flexibility is important given that certain winter conditions can prove unsuitable for any successful tracking.

Access is a critical consideration in designing track surveys. Without suitable access for motorized vehicles, the logistical effort to survey an area of sufficient size may be prohibitive. Use of snowshoes and skis for tracking under heavy snow conditions, as occur in much of British Columbia’s mountainous terrain, is slow and arduous work. Under most conditions and for most species, snow-machines will be the vehicle of choice. Transects for fishers should exclude openings in the cover which are greater than 3 m across, as fishers rarely cross wider openings. Suitable transects would include seismic lines, hiking and snow-machine trails. For the canids, felids and in some areas, wolverine, a 4x4 truck may be appropriate if access is sufficient because these species will use minor roads. However, the use of roads by lynx and wolverine varies, depending on the area and intensity of traffic.

Grid Cells, when these are used, are based on the home range sizes of target species, as are transect lengths. Those species having large home ranges and low densities require a greater sampling effort. Considering the size of their home ranges, aerial track surveys can be an appropriate method for surveying wolverine and covering an area of sufficient size more easily than on the ground. This species produces a distinct pattern that is identifiable from the air by trained observers. The landscape must be such that openings allow the observer to search for tracks. Forested habitats are not precluded from air surveys, if tracks on the ground are visible through the trees.

Office Procedures

- Review the introductory manual, *Species Inventory Fundamentals*.
- Identify objectives, delineate the Project Area, and select appropriately-sized Study Area(s) within the Project Area in which you will actually sample. These may be based on some stratification if appropriate.
- Overlay a grid onto each Study Area to delineate sample units (single Grid Cells). Suggested Grid Cell sizes are: coyote 10 km^2, red fox 2 km^2, bobcat 50 km^2, wolverine 100 km^2, fisher 25 km^2. Suggested sample units for lynx are 20 km^2 in southern British Columbia and 8 km^2 during population highs in the rest of the province. A Grid Cell sample unit for lynx during population lows would be in the 500 - 700 km^2 range. Track surveys at this inventory level are not recommended for lynx during population lows, except for southern areas which do not experience large fluctuations in hare and lynx numbers. These Grid Cell sizes may be altered if local knowledge or research supports alternatives. Select more than one cell from the grid, especially for low density populations. If many Grid Cells are available of equivalent habitat quality, select those to be sampled randomly.
- Often the transects chosen will be determined by the access available. In northeastern British Columbia, seismic lines are extensive due to oil and gas exploration while in the northwest, many areas lack any access. As noted above, forestry roads may be suitable for some species.
- On a map or air photo of appropriate scale for the Project Area (1:20,000 or 1:50,000 recommended), locate, draw, and separately label transect lines. If a map is used, be sure it is referenced to NAD83. Target high quality habitats and travel routes and use start and end points that are easily located on the ground (Hatler 1991).
- A rule of thumb is to set transect length to the square root of the sample unit (in this case, a Grid Cell), for example, 10 km for wolverine and 5 km for fisher. However, the appropriate length of transect is area and habitat dependent. The probability of detecting a species will increase with increasing length of total transects within a habitat. In low density populations where presence is questionable, the most appropriate transect length is the square of the largest documented home range size. For wolverine this would correspond to a 100 km transect.
- Plan to initiate surveys as soon as snowfall is sufficient to provide a base for snowmachines or skis / snowshoes. Starting later in the season will require much breaking of trails which becomes labour intensive as snow accumulates, and with short winter days, leaves limited time to conduct surveys.
- Once in the field, pre-planning and flexible scheduling are the keys to success. Observers must be ready to move when suitable conditions pertain (ideally, 24 hours after a fresh snow, and preferably without extreme temperatures or strong winds immediately before or during the transects).
- The same timing criteria apply to aerial surveys of wolverine tracks. Tracks are best observed immediately after a fresh snowfall and are most obvious during sunny or slightly overcast days. Days with “flat” light conditions are not suitable for tracking. Fixed wing or helicopter are both suitable aircraft. The latter permits landing to verify tracks, important if wolverine are very rare and if establishing presence is critical.

Sampling Design

The design is one of systematic sampling (transects) stratified by habitat type, where only the best habitats are surveyed. These are selected based on documented habitat relationships and on the presence of confirmed and unconfirmed sightings. Depending on the nature of the Project Area, surveying low quality habitats when the objective is to determine presence can be waste of time. However, in some cases, it may be necessary to demonstrate that a documented level of effort produced no detections.

Sampling Effort

Experience with the target species in different kinds of habitats is required to establish recommendations for sampling intensity. In most cases, large areas need to be sampled intensively for wide ranging species such as wolverine, bobcat, and fisher. Sampling effort will also be a function of the study objectives. If establishing presence is critical, surveys of the same area should be replicated throughout the winter using the same transects.

Personnel

Personnel and time requirements depend upon the target species, the number of transects required, the physical features of the Project Area, the mode of transportation, and access. Snow tracking is specialty work and experienced observers are required.

A good tracker has an understanding of animal movements and behaviour, and can recognize and identify tracks and gaits under a variety of snow and weather conditions. Acquiring this skill takes time and experience, augmented by a good teacher(s) or good guides. There are many field guides to animal tracks. Zielinski and Kucera (1995) is a good reference as they provide photographs and drawings of tracks of all species of medium-sized carnivores. Other useful references include Murie (1954), Halfpenny and Biesiot (1986) and Taylor and Raphael (1988).

- Aerial tracking of wolverine requires personnel experienced with identifying these tracks from the air.
- Snow-tracking should always be conducted in teams of two people.

Equipment

- Maps (showing transects).
- Geographic Positioning System (GPS) receiver (for establishing location of transects and for identifying locations of tracks). GPS receivers are not suitable for use in all conditions, as they will not provide locations in heavily forested habitat.
- Snowshoes or skis for transects on foot in deep snow areas. Snowshoes or skis are important safety equipment as back-ups during snowmachine travel.
- Snowmobile, if terrain and snow cover allow its use. A minimum of two machines are recommended, for safety reasons and to allow the second person to monitor for missed tracks. In areas of deep snow, the first machine is used to break trail and the second person is responsible for tracking (as the lead person cannot do both).
- 4x4 truck, if survey transects consist of roads.
- Airplane / helicopter charter, if appropriate.
- Compass
- Flagging tape

- Data sheets
- A hand-held tape recorder is recommended (Hatler 1991)
- Computer and statistical analysis software

Field Procedures

- Locate and mark transect starting point, using landmarks and compass bearings as required. Permanent, labeled tags may be affixed to stakes or trees at the start and end points if the transect is to be used again. For aerial wolverine track surveys, transects should be marked on 1:50,000 topographic maps. These will serve as flight lines.
- Tracking should begin in early winter as soon as there is sufficient snow.
- Light is an important factor in seeing and identifying tracks. Dawn and dusk should be avoided. Tracks during aerial surveys are best seen during sunny or slightly over-cast days. The flat light which results from heavy cloud cover is not appropriate for aerial tracking.
- Flat light conditions on the ground generally occur when it is snowing; snow-tracking should not be conducted during these times.
- Tracking by snowmobile should be slow (less than 5 km/hr) to prevent missing or running over tracks. At all suspected tracks of the target species, the observer should stop and ascertain the species. Back-tracking may be necessary in less than perfect snow conditions.
- Tracking by truck should also be slow (5-10 km/hr) to prevent missing tracks. An observer is recommended.
- Tracks of the target species with their location (GPS location, compass bearing, location on topographic map or air photo) are recorded.
- Hand-held tape recorders are useful on long transects as they facilitate the recording of information. If a tape recorder is used, observers should be sure they are still collecting all the data required on the RIC standard data forms.

Data Analysis

- The objective of this survey is simply to evaluate presence in different Study Areas, which may be different habitats, and no statistical analysis is warranted. A table showing which Study Areas (or Grid Cells if these are used) contain carnivores would be appropriate. The effort (km-days) expended to detect presence should be recorded for rare species. This is termed “latency to detection” (LTD) by Zielinski and Kucera (1995).
- It is also useful to produce a map which shows areas or Grid Cells which were searched and the locations of sightings and sign.
- Relative abundance studies utilize detection rates, which may be expressed as the number of individual tracks encountered per km. If investigators choose to quote such measures for a presence/not detected survey, they should qualify the limitations of these statistics, especially as many presence/not detected surveys are not properly designed for comparison of abundance.
- Incidental observations of non-target species, especially those which are red or blue-listed are valuable and can be submitted to the province, preferably on Wildlife Sighting Forms.

3.4.2 Bait/Scent stations

This method is a form of trapping in which evidence of an animal's visit, rather than the animal itself, is captured. Such evidence may consist of tracks, a photograph, hair or scats. Tracks may be captured using snow as substrate, or artificial media such as a sooted aluminum plate or sand. The same considerations of identifying tracks on snow-transects apply to identifying tracks at bait/scent stations.

The successful use of bait/scent stations is as complex as trapping. The physical structure of the set, the type of attractant, the general behaviour of the species, the age and sex of the individual animal, its prior experience with traps, its physical condition, and weather conditions all influence the success of obtaining animal sign. Authors in Zielinski and Kucera (1995) discuss considerations for establishing bait sets for fisher, lynx and wolverine. However, success in one area does not guarantee similar results in a different area, even with the same species. Local trappers familiar with the target species are good sources of information on suitable trapping methods.

Visitation rates in most areas will be low because carnivore densities are typically low. Effort to “capture” low density species must be intensive. Wide ranging species such as wolverine and bobcat may not even encounter bait stations if the period of operation is short and the Study Area is small. Snow tracking at large bait is recommended for these species. Bait /scent stations are recommended for detecting fishers, bobcats, lynx in southern British Columbia and badgers if these can be established and monitored for extensive periods (weeks or months). Operational trials in existing research areas, where animals are radio-collared, may be required to determine the necessary sampling intensity.

In most cases, snow will be a suitable medium for registering the tracks of animal visitors. Artificial media such as sand and sooted aluminum plates are described because of their prevalence in the literature. The majority of efforts using these methods have been undertaken in the United States, primarily for canids and for rare species. Generally they are used in areas where access is extensive and snow conditions for tracking are unreliable. They are impractical for use in remote areas. The application of these methods to British Columbia may be limited to only a few species and in select circumstances. However, in these cases and when snow tracking is not a viable option, sooted plates provide a means of obtaining tracks.

Remote cameras are always used in conjunction with bait/scent stations, even if the primary objective is to obtain a photograph and not tracks. Unlike bears, medium carnivores do not use traditional trails and must be attracted to the station. Hair snares and scats provide additional information, especially where tracks are ambiguous, and may allow confirmation of species. They are not meant to be used alone to detect presence (although incidental samples of hairs or scats can be analyzed if collected).

Foresman and Pearson (1998) compared three methods to detect marten, fisher and wolverine: remote cameras, and exposed and closed sooted track plates. They used a 10.4 km^2 sample unit with stations placed 0.8 km apart. Non-rewarding baits (deer quarters) and commercial trapping lures were the attractants. Track plates detected marten and fisher but not wolverine. Although marten appeared to visit open track plates more rapidly, heavy rains rendered them useless but did not affect the covered track plates. They recommended open track plates in good weather and both types when the weather was unfavourable. Cameras ranked better in detection success, species identification and in implementation effort. The track plates scored better in latency to first detection and cost.

The authors noted that season could have been a factor as remote cameras were used in winter and track-plates in spring, according to recommendations in Zieliniski and Kucera (1995). Zielinski and Kucera (1995) reported longer LTDs for line-triggered cameras, and suggested that track plates may produce shorter LTDs. Conversely, Bull *et al.* (1992) conducted a simultaneous test of line-triggered cameras, track-plates and snow-tracking for detecting marten. Due to poor snow conditions, covered track-plates provided the highest rates of detection. However, tracks were not easily identifiable on the plates. The cameras detected marten but less often than the other techniques.

There is no guarantee that sooted track plates will provide tracks of better, or even equivalent quality, to those left in snow. Foresman and Pearson (1998) cautioned that under field conditions, 87% of tracks on sooted plates were not of sufficient quality for confident identification. Where the target species is very rare, and it is not possible to snow-track, confirmation of species from hair or a photograph may be critical.

Baits and Scent

In general, scent alone is used to attract felids and canids while bait in combination with scent is used to attract mustelids. Stations in which no bait is provided are referred to as “scent stations”. Large scale inventory studies for felids and canids have been conducted in the United States for many years. A fatty acid scent (FAS) was selected as "the standard" for canids after a series of field tests (Roughton 1982). FAS also attracts the other species of medium-sized carnivores, but other scents may be better for non-canids. For example, Rolley (1987) reports that in one area, scent station visitation rates for bobcats were increased by using bobcat urine rather than FAS. Further, bobcats were more strongly attracted when the tracking substrate was agricultural lime rather than natural soil.

Presentation methods for scent lures vary. An inexpensive, convenient to handle, and simple to prepare method was developed by Roughton and Sweeny (1982). They saturated plaster discs (cost about $.01 each) with the scent lure outside or under a fume hood, drained and sealed them in glass jars, and handled them with tongs or forceps in the field to minimize contamination of skin and clothes. That proved to be a favorable alternative to the use of plastic capsules (expensive), plaster-wax discs (complex preparation), and liquid (expensive and logistically difficult).

Carrion or road-kills are suggested baits for attracting fisher, badger and wolverine. Discards from butcher shops, especially pork, are aromatic and also can be used. Some wolverine may not be attracted to small bait, and some researchers believe that a large reward, such as an entire carcass, is necessary to attract animals. However, the attraction may not necessarily rely on the size of the bait so much as the magnitude of the smell it produces. Large baits produce a strong odor which may be more successful at drawing in animals which are widely-spaced, like wolverine. It may be possible to achieve this effect using smaller, unattainable baits in conjunction with large amounts of scent, such as commercial scent lures or fish fertilizer (E. Lofroth pers. comm.). The best technique is to place the bait stations in suitable habitat and to monitor these for long periods of time (up to 30 days). Stations are checked every other day for visitations by tracking in the surrounding snow. A remote camera is also recommended. This method has successfully detected wolverine in low density populations in Idaho (*in* Zielinski and Kucera 1995).

Cameras

The use of remote cameras to obtain photographs of bait /scent station visitors (Zieliniski and Kucera 1995, Jones and Raphael 1993) represents a more reliable (though more expensive) alternative to track interpretation. Cameras may be triggered by the animal pulling fishing line which is attached to the trigger (110 system) or by completely remote 35 mm systems equipped with heat and motion sensors and a 12 V battery for power. The former is relatively inexpensive ($25/unit) but labour intensive. If the camera is set off by a non-target species, it is non-operational until it is re-set (as the film does not automatically advance), possibly losing the opportunity of taking a picture of the real target. The latter is expensive ($400/unit) but can be left unchecked for longer periods. Although a non-target species will not disable the camera, frequent visits can result in many pictures being taken of the same animal, and filling up the roll. There are also differences among brands of remote cameras. Foresman and Pearson (1998) recommend Trailmaster® cameras over the heavier, less efficient Manly camera. Cameras have successfully detected all members of the inventory group but badger.

Sand / Sooted Track Plates

Sand (Conner *et al*. 1983), or sooted (also known as “smoked”) aluminum track plates (Barrett 1983) have been used to provide better track registration at bait/scent stations. Where moist sand is available, it is raked into a 1 m circular plot at the entrance to the cubby. Sand is used during non-winter seasons, which is not recommended for bait/scent stations in British Columbia. The most common artificial media are aluminum plates sooted with the smoke from an acetylene torch. These plates can either be covered or left uncovered but are usually placed in a cubby situation where the animal is forced to walk on the plate in order to obtain a reward, a bait or scent.

Because tracks on the sooted plates are negatives, Taylor and Raphael (1988) developed a key to tracks of 23 species for that medium. Zielinski and Kucera (1995) however, recommend placing sticky white paper (sold by the trade name Con-Tact®, and typically used to line drawers and cupboards) behind the sooted plate to obtain a positive print instead of the negative left behind on the sooted plate. Track plates have successfully detected fisher, bobcat, badger, fox and coyote but not lynx or wolverine (Zielinski and Kucera 1995).

Hair Snares

The cuticular pattern in hair is unique to species and can provide absolute confirmation. Guard hairs are required. Identifying species is a relatively simple procedure which involves examining the hair’s cuticular pattern under a dissecting microscope (Kennedy and Carbyn 1978). Although there are a number of reference keys available, if samples are available, investigators can develop their own key.

Although more complex than examining hair cuticles and requiring a specialized lab, DNA in hair roots can also be used to indicate species and sex and identify individuals (Foran *et al.* 1997), which has application for determining relative or absolute densities. Polymerase chain reaction techniques are used to determine species and gender, and microsatellite DNA fingerprinting to identify individuals.

The time of year is an important consideration when collecting hair for DNA analysis. As intact roots are necessary, the shedding period should be avoided. Krebs and Lewis (1998) note that for wolverine, it appears that hair is well-rooted into April and shedding is not underway until the latter part of April. Hair collected from the inventory group any time during winter is expected to be suitable for DNA analysis.

Collecting hair from a wild animal requires baiting a substrate that will "grab" hair in such a way that an interested animal is forced into contact it. Several different substrates have been put to this use. Raphael (1994) described a number of earlier studies that used barbed wire in a variety of configurations, or PVC (polyvinylchloride) tubes baited with sticky material, all of which obtained some hair of *Martes* species. However, all these studies report low detection rates, possibly due to variable methods and effort (Raphael 1994).

Foran *et al.* (1997b) describe using glue-boards to snag hairs of marten. These are available commercially as glue traps used to entangle mice and rats. They placed hair-snares within a wooden cubby with an entrance at each end. The cubby was attached to a tree trunk at chest height above the snow-pack, with the bait loosely attached to the center of the tube. Patches (3x3 cm) were cut from large shallow trays of plastic-backed glue traps and tacked midway between the bait and each entrance so that marten were obligated to rub against the glue boards. Foran *et al.* (1997b) note that while glue patches are effective for grabbing hair, at least for marten, they are difficult to work with, both in the field and in the lab.

John Weaver (USDA Forest Service, Missoula Montana) used the behaviour of a lynx to rub its neck while scent-marking to obtain hair. A 4 inch square piece of carpet studded with tacks and scented was affixed to a tree at lynx height. A visual attractant, such as a dangling feather or aluminum pie plate, was used to attract lynx. The lynx readily rubbed on the carpet, leaving hair behind which successfully provided DNA. The utility of this technique as a means of determining relative and absolute abundance is currently under investigation (J. Weaver pers. comm.).

Krebs and Lewis (1998) conducted limited trials of hair-snaring for wolverine at live-trap sites including barbed wire and different configurations of glue-boards situated on running poles, inside and outside of wooden cubbies. Hair samples were obtained from all methods, however only the barbed wire samples appeared to have DNA containing follicles, although this requires confirmation.

Species Identification from Scats

As noted in the species descriptions, the classification of scats according to species by morphology is subjective and can be confounded by a number of factors. For example, the scat of carnivores, such as those in this inventory group, may contain DNA from numerous prey species, increasing the complexity of laboratory work. Attempts to determine species from scats using pH or bile acids (Quinn and Jackman 1994) have proved futile. Foran *et al.* (1997a) report on the identification of species using DNA present in scats. They were successful in obtaining DNA from the scats of 14 species of North American carnivores including coyote, badger, fisher, bobcat and lynx. They note that differences among areas do occur and caution that the local population under study should always be analyzed using appropriate reference samples.

Office Procedures

- Review the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Identify objectives and delineate the Project Area.
- Grid Cell sample unit sizes are the same as those recommended for snow-tracking surveys (Section 3.4.1): coyote 10 km^2, red fox 2 km^2, bobcat 50 km^2, wolverine 100

km^2, fisher 25 km^2, and badger 32 km^2. Suggested sample units for lynx are 20 km^2 in southern British Columbia and 8 km^2 during population highs in the rest of the province. A Grid Cell sample unit for lynx during population lows is in the 500 - 700 km^2 range. These Grid Cell sizes may be altered if local knowledge or research supports alternatives.

- Areas with little-used or abandoned roads or trails are the most convenient for laying out stations. Note that if the target species is fisher, bait/scent stations should be placed under cover.
- To systematically lay out transects or stations within each Grid Cell sample unit, you will need to select intervals between survey lines and/or between stations along lines. Intervals should be scaled to the mobility of target species, but cover characteristics are also a consideration in relation to the drawing power of the scent lures used. Guidelines are provided below.
- On the map or air-photo selected, locate, draw, and label traplines and the stations along each line.
- The survey should be timed for the winter period. If possible avoid periods of adverse weather and the hunting season.
- Select the method of track/visitor identification, as described above. Hair snares, with an appropriate snagging device, or remote cameras, are recommended with all methods.
- Consult with successful local trappers on the behaviour of the target species within the Study Area and on methods of trapping.

Sampling Design

Sampling designs are species specific. Do not assume that a sampling design used in a different habitat or outside of the province will be suitable in your Project Area. Even within the province, sampling designs may need to be altered to accommodate regional differences in animal behaviour. As a result, these are general guidelines that may change over time and operational trials are recommended.

The number, spacing, and monitoring schedule for bait/scent stations may vary with study objectives, target species, and time/expense limitations. Most studies will employ a battery of stations, set up at intervals along a survey line or in grid patterns. The array of devices is placed where detections are most likely, where the habitat suitability is the highest, or where unconfirmed sightings are concentrated. In most areas, the stations are set up in transects along roads, to facilitate monitoring.

- Generally, only one Grid Cell is surveyed at one time. However, if logistics permit, especially for the smaller members of the inventory group, more than one sample unit can be surveyed concurrently. For larger sample units, additional units can be surveyed if one intensive survey has not produced results. The number of units surveyed will, in part, be a function of available resources.
- Wolverine and bobcat: Large bait stations are placed in natural travel corridors or in areas where wolverine and bobcat are suspected to occur and in areas with sufficient snow for tracking. Include hair snares and cameras.
- Large bait stations may be applicable for badger but success cannot be predicted as there are no documented attempts to detect presence using this method.
- Canids and felids: Scent stations arrayed on transects, without bait. Include hair snares and, if desired, cameras.

- Fisher and badger: Bait/scent stations arrayed on transects or on a grid. Include hair snares and, if desired, cameras. Small bait is recommended.

Sampling Effort

Jones and Raphael (1993) observe that "a relation probably exists between the spacing of the stations and detection success, but it is currently not known", and "optimal spacing and length of running time need to be researched in different areas for different target species." The following are recommended as starting points only.

- For coyotes, linear scent stations have typically been spaced at 0.5 km intervals (Linhart and Knowlton 1975, Roughton and Sweeny 1982), while a spacing of 0.32 km has been used for foxes (Conner *et al*. 1983). The suggested layout for canids and felids is 50 scent stations x 4 lines monitored for 4 days. A longer monitoring period is recommended for felids, especially in southern British Columbia where densities are low.
- Where stations are laid out in a grid pattern, distribute scent stations throughout the sample unit, concentrating on travel corridors and on high value habitats for the target species.
- For fishers, a minimum of 15 stations per 25 km^2 are recommended. Run two surveys per sample unit, set for 12 nights and check every other day.
- For badgers, a minimum of 20 stations per 32 km^2 are recommended. Three surveys per sample unit are recommended, set for 12 nights and check every other day.
- For wolverine: Two to 3 large bait stations per sample unit (100 km^2). Stations should be left for a maximum of 30 days and checked every 2-3 days.
- For bobcat: Two large bait stations per sample unit (50 km^2). Stations should be left for a maximum of 30 days and checked every 2-3 days.
- Cameras: Place remote cameras at large bait. For all other applications (Zieliniski and Kucera(1995):
    - 35 mm systems - at least 2 cameras per 10 km^2, spaced 2 km apart. Set for a minimum of 28 days and check every 7 days. Use large bait (at least 5 kg).
    - 110 systems - 6 line-triggered cameras per 10 km^2. Set for a minimum of 12 nights and check every other day.

Personnel

Individuals monitoring bait/scent stations must be familiar with track identification for target species. Useful references include Murie (1954), Halfpenny and Biesiot (1986), Taylor and Raphael (1988) and Zielinski and Kucera (1995).

Equipment

- Maps or air photos (1:20 000 or 1:50 000)
- Cubbie materials (plywood or plexiglass; construct prior to entering the field)
- Plastic bags for collecting scats and labelling markers
- Gloves
- A suitable attractant, scent or bait:
    - For canid and felid scent stations: Plaster discs saturated with FAS (fatty acid scent, see “Bait/Scent” above and Roughton and Sweeny 1982) or a suitable alternative; 1 disc for each scent station

    - Tongs for handling plaster discs
    - An alternative for felids is to use the Weaver carpet hair snare impregnated with an appropriate felid scent. This may consist of a commercial trapper's lure or lynx or bobcat urine, if available. Weaver concocted a scent which included Chanel No. 5® perfume and lynx urine (J. Weaver pers. comm.). Investigators may opt to make their own scents. Trappers are good sources of information for successful lures.
    - Visual attractant for lynx and bobcat. Shiny objects such as aluminum pie plates seem to work well, as do dangling feathers or bird wings
    - Bait consisting of pieces of decayed meat, wild or domestic
    - Large bait (whole carcass of road killed or domestic ungulate), for wolverine and bobcat
- Data sheets
- Detection Media: (Detailed information on sooted plates and cameras can be found in Zielinski and Kucera 1995)
    - <u>Sand</u> - Moist, sifted sand (enough for a circular plot of 1 m radius at each scent station); sand sifter.
    - <u>Sooted Aluminum Track Plate</u> - plywood (for building cubby), 40 x 80 x 0.1 cm (16" x 32" x 1/16") aluminum flat stock (sold in hardware stores), Con-Tact® paper, acetylene torch, duct tape. Soot the plate prior to entering the field or when in the field, whichever is most practical. Flexible plastic can also be used as a cover for track plates.
    - <u>Remote Cameras</u> - Detailed information on appropriate camera systems should be obtained from the manufacturer as systems will change with time. Currently, two basic types are available, a) a line triggered 110 mm camera b) a dual sensor remote 35 mm camera.
        - Most models for the line-triggered camera are appropriate if they have an internal flash. The system consists of the camera, a wooden mounting stake with a wooden platform, a cover from a large plastic milk jug, and the trigger mechanism. Fishing line from the bait connects directly with the shutter mechanism inside the camera.
        - Remote 35mm cameras are either triggered by an infrared sensor (single-sensor) or by microwave action and a passive infrared heat sensor (dual-sensor). The camera is powered by a 12V battery and the entire system is encased in a weatherproof ammunition box. It comes with a mounting bracket and lag bolts for attaching to a tree.
    - <u>Hair Snares:</u> As described above, a variety of hair-snares can be used. Although personnel are encouraged to experiment with different hair snagging media, rodent glue traps and barbed wire appear to be the most appropriate for the target species.
        - Rodent glue traps ("glueboards"). These come in two sizes: 13 x 20 cm boards (for mice) and 46 x 51 cm (for rats). Either can be cut to size as appropriate.
        - Barbed wire is available at many outdoor / farming supply stores in large rolls and can either be double-stranded or single-stranded. It should be cut into pieces for transport into the field. Care must be taken to avoid puncturing skin or clothing.

    - Remember to bring tweezers, paper envelopes, polyvinylchloride (pvc) vials, silica desiccant, for collecting hair

- Computer and statistical analysis software

Field Procedure

- Establish traplines and bait/scent stations at pre-determined locations (see Office Procedures, Sampling Design and Sampling Effort).
- For each bait/scent station:
  - Avoid human scent, if appropriate, by handling all equipment with gloves and refraining from leaving much human scent at the station (canids and felids).
  - For all species, baits should be placed at the back of a cubby as if the objective is to trap the species. Note that trapping techniques are species and area specific and if the observer does not have appropriate experience, local trappers should be contacted. General guidelines, however, can be provided:
  - Cubbies for fishers consist of a wooden box (about 60 long x 30 wide x 26 cm tall) which is either placed on the ground or elevated by attaching to a tree trunk or tree limb about at chest height. Fishers hunt in openings within coarse woody debris and under the snow; the cubby mimics such an opening. One end may be blocked with a wire mesh or left open. The bait is hung toward the end of the cubby, if blocked, or the middle, if open on both ends. Hair snares, if used, are tacked on either side of the bait. If sooted plates are being used ensure that the cubby is large enough to receive the plate.
  - For lynx and bobcats, a cubby may or may not be used. If used, it is constructed of thin branches found in the surrounding area "tented" around a suitable tree. The scent is placed on the tree (FAS or other scent). A visual attractant such as a hanging feather, bird wing or pie plate is attached to a tree branch so it will be blown about by the wind and will be visible to cats traveling in the area. Scent and a hair snare can be combined in one media by using the Weaver carpet square.
  - For canids, choose a site which is visible and adjacent to the travel route. Place the scent at the base of a tree. A cubby is not necessary unless the animal's movements must be directed towards the attractant. In that case, use guide sticks placed in the ground to direct the fox or coyote where to step.
  - For large bait stations, hoist the carcass in between two trees using rope, suspended 2-3 m above the ground. Include hair snares. A remote camera is recommended. If smaller, unattainable baits are used, these may be placed in metal boxes and firmly fixed to trees.
  - As there is little information available on the trapping and behaviour of badgers in the province, establishing a successful bait/scent station for this species will be trial and error. As badgers are burrowers, for stations arrayed on a grid or transect system, a cubby consisting of a large rectangular box, as described for fishers but badger-sized and placed on the ground, is recommended. Small bait is placed inside the box.
  - If necessary, provide suitable conditions for tracks by raking snow in vicinity of the station. If sooted plates are being used, place plate within the cubby (enclosed plate) or on the ground (exposed plate), as described below.
  - At each check of the station and after identification of tracks and collection of hair or scats, refresh bait and scent and rake the snow to obliterate existing tracks.
- The following field procedures refer to media for registering sign such as tracks, hair and photographs:
  1. Sooted Track Plates:

- After the plate is sooted, wrap a piece of Con-Tact® paper with sticky side up and backing intact around the plate and tape it to the back of the plate. Align paper so that is slightly rear of the center of the plate but with 9 cm of exposed plate beyond it where the bait is placed.
- The plate is either placed in a plywood cubby or covered with a flexible plastic tent.
- For an exposed track plate, Con-Tact® paper is not used. The plate consists of two 40 x 80 x 0.1 cm sooted plates laid side by side on the ground. The bait is placed in the center.

2. Remote Cameras:
   - Follow procedures outlined in Sampling Effort
   - For line triggered systems, place the camera and bait at appropriate height and location for the target species. Note that snow can interfere with the trigger line.
   - For remote cameras, affix the camera to a tree focusing on the bait. The first roll should be a test 12 exposure role to ensure the camera is working properly. Have the assistant simulate the target animal.
   - Ensure completed rolls are labeled with the date in/out, the station name and the location.
3. Hair Snares: Although the following should result in successful capture of hair, investigators are encouraged to experiment with different media.
   - For wolverine at large bait sets, string barbed wire between trees so that the animal is required to rub the barbs, leaving guard hair behind. Wire should be strung tight, surrounding the bait like a corral with multiple strands. This will encourage contact with a curious animal, even as the level of snowpack changes.
   - For canids, strategically place barbed wire on trails leading to the cubby so that the animal is forced to walk under the barbed wire.
   - For bobcat and lynx, affix the tacked carpet to a tree at about 30 cm off the ground, so that it is at a height that the animal will rub. Saturate the carpet with a scent appropriate for felids.
   - For fishers and badger, either glue (mouse/rat traps) or barbed wire are recommended. Place within the cubby so that the animal is obligated to rub past and leave hair behind.
   - If it is possible, hairs should be retained for future DNA analysis, even if it is not an objective of the current study. However, hairs which will be analyzed for DNA require more careful treatment than hairs collected for assessment using cuticular patterns (Foran *et al.* 1997b).
     - Hair-snares should be checked frequently to avoid DNA degradation and to reduce the chance of multiple captures. Hairs should be handled with tweezers, avoiding the roots, placed in paper envelopes, labeled appropriately and dried.
     - Hairs which are encased in glue (from glue traps) should be placed in polyethylene vials half filled with silica desiccant. The person collecting the sample should NOT attempt to remove hairs from the glue in the field.
     - Tweezers should be cleaned in between samples to prevent genetic contamination.
     - Samples are stable at room temperature but long-term storage at -20^0C or colder is recommended. Note that warmer temperatures and direct solar radiation promote the degradation of DNA (Foran *et al.* 1997).

4. Scats
    - Because DNA degrades over time, the condition of the scat is important and samples need to be collected as fresh as possible and preserved quickly. It is also paramount that contamination through human contact or cross-contamination does not occur.
    - Samples should be collected in new plastic bags, labelled and frozen immediately upon returning from the field.
    - Storage of a small portion of the scat with excess silica desiccant in a polyvinylchloride (PVC) tube is also acceptable.

- Monitor bait /scent stations as per study design. Data are recorded as "visits" (one or more tracks of a species at a station). Individual tracks are not counted. Hair, scat or photographs are recorded as a visit.

Data Analysis

- One animal visit is represented by one or more tracks (or hair, scat, photograph) of a species at one station in one day.
- Delete inoperative station nights, those in which absence of tracks (i.e., no apparent animal visit) was believed the result of extraneous factors, usually obliteration by wind or rain.
- Calculate latency to detection (LTD) as the number of station-days required to achieve a detection in a Grid Cell, similar to expressing trapping success as number of trap-nights per successful capture. Also report the Grid Cell size.
- Hair Identification:
    - It is possible to identify some species by hair colour, length and texture. For accuracy, species are identified by comparing the cuticular pattern of the guard hair to that of a known specimen. An impression of the hair is made on coloured green acetate. The hair and acetate are sandwiched in between two microscope slides and heated over a bunsen burner. The cuticular impression left on the acetate is viewed under a compound microscope. Keys to hair identification guides include Day (1966), Moore *et al.* (1974), Adjoran and Kolenosky (1980) and Titus (1980). Alternatively, a key can be developed from known specimens.
    - DNA analysis, of hair and scats, is conducted by specialized labs. These are documented in the manual no. 21, *Inventory Methods for Bears*. For hair embedded in glue, Foran *et al.* (1997b), describe the use of solvents that dissolve glue without degrading the DNA.

3.4.3 Den Search

Den searches are a specialized method of evaluating the presence of coyotes, red foxes and badgers. Although snow-tracking or bait/scent stations are preferable methods for determining the presence of coyotes and foxes, den searches may be used where denning habitat is known, can be identified, and occurs in relatively open areas.

The most efficient method of searching for active canid dens is by airplane or helicopter. Ground investigation is needed for confirmation of use (live animals, scats, prey accumulations).

Dens for badgers include maternal dens and active burrows; either can confirm presence. Aerial den searches should also be applicable for badgers but this technique will require some investigation and refinement. For ground searches, a greater area can be covered by horseback. Burrows must be investigated for sign to confirm they are in use (fresh diggings, tracks). Den searches for badgers do not need to be limited to the period when maternal groups are present. However, as badgers enter a state of inactivity some time between December and March, this period should be avoided.

Office Procedures

- Review the introductory manual, *Species Inventory Fundamentals*.
- Identify objectives, delineate the Project Area, and select appropriately sized Study Area(s) within the Project Area in which you will actually sample. Overlay a grid onto the Study Area, and use the Grid Cells as sample units. Unless other information suggests that denning areas are clumped, Grid Cell sizes are: coyote 10 km^2, red fox 2 km^2, badger 50 km^2.
- If more than one Grid Cell sample unit is available for survey for a target species, select the one(s) to be surveyed randomly.
- For canids, on a map or air photo of appropriate scale for the Project Area (1:20,000 or 1:50,000 recommended), locate, draw, and separately label transect lines. These should be parallel and cover the entire sample unit (Grid Cell). They will serve as flight lines. A distance of 1 km between transects is recommended for canid den aerial searches.
- For badgers, mark the areas to be searched on a map or air photo (1:20,000). The distance between transects for badgers will be a function of the terrain, whether walking or on horseback, and should be determined once in the field.

Sampling Design

The sampling design is one of systematic sampling within identified denning habitat. As the search effort is intensive, replication within the same season is not recommended. Additional sample units should be searched if initial efforts yield no results.

Sampling Effort

Effort will be a function of the number of sample units that must be searched and animal abundance. For the canids, aerial searches can likely be completed in a few hours. The time required for ground confirmation of use will be a function of the number of dens found and access.

Ground searches for badger dens can be intensive.

Personnel

Personnel familiar with dens and activity sign of the target species are required.

Equipment

- Maps or air-photos at 1:20,000 or 1:50,000
- Geographic Positioning System (GPS) receiver (for establishing location of dens) is recommended
- Airplane / helicopter charter, if appropriate
- Compass
- Binoculars
- Data Sheets
- Computer and statistical analysis software

Field Procedure

- For canids, grid cells are searched using transects during the denning season, June and July. Do not initiate the study too early or canids may abandon their dens.
- For badgers, surveys can be conducted at any time but avoid the period from December through March. Avoid motorized vehicles during the period when badgers are having their kits. Horseback surveys are recommended.
- If an aircraft is used, the altitude of the aircraft should be at least 1000 feet above ground level (agl).
- Follow up aerial surveys with ground confirmation that dens are actually in use.
- Record locations of confirmed dens (referenced to NAD83).

Data Analysis

For each sample unit:

- Provide maps of Grid Cells searched and the transects used during the searches.
- Report locations of confirmed dens.
- Report latency to detection, the number of search days required, and the total area searched to detect an active den.

3.5 Relative Abundance

Recommended method(s): Snow-tracking surveys, where feasible, are recommended for determining relative abundance. Given that badgers are wide ranging and that the population is very small, the likelihood of success using this method is extremely low. Relative abundance inventory is not recommended for this species.

When determining relative abundance using track surveys, the assumption is made that the numbers of tracks counted are an accurate reflection of the activity of animals within that habitat or that area, and secondly, that activity is related to the numbers of animals. Thus, a comparison of areas should be an accurate reflection of the difference in abundance of animals between those areas. As track surveys are not biased by bait/scent, and given similar weather and snow conditions, these assumptions are likely true.

Pilot projects to determine optimal sampling designs and sampling effort are recommended. To this end, programs like MONITOR (Thomas and Krebs 1997) can be useful. Pre-monitoring evaluations of statistical power are essential and will assist in determining the effort necessary to achieve the desired objective. These planning exercises are especially important if the objective is to use snow-tracking as a tool for population monitoring, rather than comparing activity of animals within different habitats. It can require an intense effort on the part of the investigator to move from a comparison of activity to one of actual abundance.

For low density species, the conclusion after careful evaluation may be that it is not statistically valid or economically feasible to conduct population monitoring using inventory methods and that demographic studies to estimate growth rate may be preferable (Zielinski and Kucera 1995).“To embark on a monitoring scheme without complete familiarity with the detection method, without consultation with a competent statistician, and without simulating possible monitoring scenarios is a waste of time and money” (Zielinski and Kucera 1995).

3.5.1 Snow-tracking

Winter track count transects have been commonly used to assess the relative abundance of terrestrial furbearers, either in population assessment (Slough and Jessup 1984) or, more commonly, as a tool to assess the effects of habitat alteration due to forestry or mining practices (Penner 1979; Gyug 1988; Thompson *et al.* 1989). Although it is the technique that readily comes to mind when assessing furbearer populations, the majority of efforts are poorly planned or conducted using inexperienced observers with the result that erroneous interpretations are drawn from data that were improperly collected for the species in question. However, if properly designed and executed, snow-tracking can be a powerful tool for the assessment of populations and their habitats and in assessing changes over time.

Office Procedures

- Review the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Read *Section 3.4.1*. The considerations involved in using snow-tracking to determine presence/not detected are the same as for determining relative abundance.
- Identify objectives, delineate the Project Area, and stratify by the appropriate habitat level to account for behaviour of the target species and meet project objectives.
- Transect length may be variable (Slough and Jessup 1984; Gyug 1988) or uniform (Thompson *et al.* 1989) in length, the former more common to accommodate spatial changes in habitat type.
- A rule of thumb for transect length is the square of the typical home range size, for example, 20 km for wolverine (400 km^2 home range) and 5 km for fisher (25 km^2 home range). In low density populations where presence is questionable, the most appropriate transect length is the square of the largest documented home range size. The transect should be long enough that the target species with the largest home ranges will be detected.
- Select transects that cover habitats in proportion to their occurrence. Often the transects chosen will be determined by the access available. Assess seismic lines, forestry roads, right-of-ways, snow-machine trails and ski trails.
- On a map or air-photo of appropriate scale for the Study Area (1:20,000 or 1:50,000 recommended), locate, draw, and separately label transect lines, in reference to habitats of interest. It is a good idea to use start and end points that are easily located on the ground (see Hatler 1991).
- Pre-planning and flexible scheduling are the keys to success. Observers must be ready to move when suitable conditions pertain (ideally, about three days after a fresh snow, and preferably without extreme temperatures or strong winds immediately before or during the transects).

Sampling Design

- A preliminary survey should be conducted to assess the precision of snow track counts before any large-scale inventory is conducted. In the preliminary survey, snow track counts should replicated along the same route over a short time interval to give an initial estimate of precision. This estimate of precision should be used with power analysis packages such as MONITOR, POWER AND PRECISION, and NQUERY. These surveys will provide information on the sampling effort necessary to achieve the desired precision and accuracy, given the Type I and Type II errors that are acceptable to the investigator.

- The study design is one of systematic transects, stratified by habitat. Transects should cover habitats in proportion to their occurrence (Thompson *et al.* 1989). The spatial scale of habitat stratification is species dependent and can range from ecosection to the biogeoclimatic zone variant level.
- If the objective is to compare areas, optimally they should be surveyed simultaneously. If this is not possible, one area should be surveyed immediately after the other, to ensure external factors are equivalent. Even if weather conditions are not optimal for snow-tracking, the assumption is made that animal behaviour is affected the same way in both areas, and the observer's ability to identify tracks is the same in both areas.
- Tracking should begin as soon as there is sufficient snow and appropriate conditions for tracking, to avoid the bias of over-winter mortality. Note that the presence of commercial trapping or hunting activity will complicate inventory efforts and can bias results, especially for species such as fisher which are attracted to baits and easily trapped.
- Surveys should be replicated over a short period to reduce the statistical variance inherent to transect data (Harris 1986) guided by results from the preliminary survey(s).
- Snow tracking should not be conducted in conjunction with bait/scent stations or traps as these will attract animals and alter their behaviour.

Sampling Effort

Sampling effort depends on objectives, the target species, the habitats being surveyed and topography. As indicated, preliminary surveys are essential to indicate the amount of replication necessary to achieve the desired precision.

Personnel

- As documented in Section 3.4.1, Presence / Not Detected.

Equipment

- As documented in Section 3.4.1, Presence / Not Detected.

Field Procedure

- As documented in Section 3.4.1, Presence / Not Detected.
- Each track that crosses or "intercepts" the transect line is counted. Because the determination of individuals is seldom possible, all interceptions are counted even if they were made by the same animal.
- The observer keeps track of distance and location along the transect, using a hip chain or odometer, or by marking it on a 1:15,000 or 1:20,000 map or air photo.
- Data should be recorded as either 1) the number of tracks of each species counted along each 100 m segment of the transect, or 2) the location of each track as encountered on the transect. If microhabitats are important, associate tracks with the habitat type by describing in field notes.
- For non-motorized surveys, use of a hip chain and tape recorder allows rapid progress along a snow transect with relatively precise measurements at each track intercept, and

the resulting data can be assembled in relation to whatever track segment lengths are deemed appropriate (one person method of Hatler 1991).

Data Analysis

- Account for the time since the last snow-fall, by dividing the number of tracks by the number of 12 or 24 hour periods since the last snowfall. Results are reported as number of tracks per km (per 12 or 24 hour period).

- Statistical analyses that explicitly utilize the properties of count data should be used. Programs designed for track count data like PELANAL (or NEGTEST) should be used for comparison of snow tracking data from different areas. Generalized linear models could also be applied to these data. If studies are designed appropriately, the following general analysis methods can be used (Boulanger and Krebs 1998, Table 2).

Table 2. RIC objectives and analysis methods for relative abundance data

Objective	Analysis Method	Programs
Trends in abundance over time	Sample methods Regression techniques Power analysis	Generic statistical packages,
Comparison in abundance between areas	Parametric, and data based methods Power analysis	Generic statistical packages, Power analysis software PELANAL or NEGTEST(White and Eberhardt 1980)
Determine whether habitat modifications have altered population size	Parametric, and data based methods Power analysis	Generic statistical packages Power analysis software

One inherent problem with count data is that they are rarely normally distributed, making the applicability of parametric methods with raw data risky especially if sample sizes are low. This is especially the case with pellet group and other count data, such as tracks, which are usually distributed as negative binomial (White and Eberhardt 1980, White and Bennetts 1996). Before data are used in parametric tests, the assumption of normality should be tested. Transformations may make frequencies appear more like a normal distribution.

Trends in Abundance Over Time

The basic methodology for determination of trends is linear regression. There are a variety of refinements to the linear regression technique that can be used with data dependent on sampling assumptions and other characteristics.

Comparison Between Areas

White and Eberhardt (1980) have developed a program (PELANAL) that compares pellet group counts using the negative binomial distribution. This program is available from Gary White at Colorado State University. This program calculates mean values, estimates of dispersion, and tests for differences between mean and dispersion using nested log-likelihood tests. John Boulanger and Charles Krebs have modified this program (NEGTEST) to use model selection routines introduced in White and Bennetts (1996).

Habitat-based Inference

Logistic regression or similar methods can be used for habitat association. This approach requires that habitat units be the primary sample unit as opposed to population units.

3.5.2 Bait/Scent stations

Bait/scent stations are NOT recommended as a means of determining relative abundance for this inventory group. This method was first developed in the 1950s to index abundance patterns of red and gray foxes (reviewed in Conner *et al.* 1983). It was subsequently adopted, with modifications, for widespread use in monitoring population trends of coyotes in the American west. Linhart and Knowlton (1975) reported on a program in which more than 300 scent station lines in 17 western states were being monitored annually. Each of those lines consisted of 50 scent stations at 0.3 mi (0.5 km) intervals, and were monitored on each of five consecutive days. Data were recorded in terms of animal visits, and expressed as an index of abundance.

There was some evaluation of optimal survey design for bait/scent stations in the Western USA (Roughton and Sweeny 1982) and in Florida (Conner *et al*. 1983), and this led to some recommendations for sampling design. However, others noted that the main limitation to the use of scent stations for monitoring abundance was that the relationship between visitation rates and abundance is not necessarily linear, either between or within species, and the nature and extent of factors that contribute to non-linearity are not fully understood or predictable. Further, visitation rates in most areas are low because carnivore densities are typically low. The result is chronic high variability (i.e., low precision) (Griffith *et al.* 1981, Rolley 1987).

Sargeant and Johnson (1997) re-analyzed field data collected in Minnesota during 1986-1993, one of the most intensive long-term applications of the scent station method, and they obtained unsatisfactory results. Statistical models fit poorly, individual carnivores had undue influence on summary statistics, and comparisons were confounded by factors other than abundance. They concluded that the statistical properties of scent-station data were poorly understood. They further concluded (Sargeant *et al.* 1998) that long-term trends in visitation rates probably reflect real changes in populations, but poor spatial and temporal resolution, susceptibility to confounding, and low statistical power limited the usefulness of this survey method.

If research on DNA analysis of hair for members of this inventory group reaches a stage of reliably identifying individuals, it will be necessary to re-evaluate the use of bait/scent stations equipped with hair-snares as a method of determining relative abundance.

3.6 Absolute Abundance

Recommended method(s): For wide ranging, low density carnivores (wolverine, bobcat, fisher) and for extremely rare carnivores (badger), live-trapping and radio-telemetry are recommended for estimates of absolute abundance. This method is not suitable for northern lynx and red fox due to their population cycles. Determining absolute abundance of lynx is recommended only for the southern portion of their range in the province.

As noted earlier, inventory efforts for the species in this inventory group are, for the most part, difficult and expensive. Investigators should be certain that only an estimate of absolute abundance can address their objectives. Snow tracking may provide an index of absolute density; however, it is not known how numbers of tracks are related to actual numbers of animals. Although a direct relationship likely exists, except for aerial track surveys of wolverine conducted in Alaska (Becker 1991), no existing sampling method is known to yield unbiased, accurate estimates of densities for this inventory group. One can, however, compare the variation in track-intercept counts against independently derived estimates of relative abundance, such as from an intensive radio-telemetry study. It is strongly recommended that capture/telemetry studies investigate the relationship between tracks and density for these species.

3.6.1 Live Capture / Telemetry

Estimates of absolute abundance for species in this inventory group have been determined from studies which attempt to capture all the animals within a given area, follow them intensively using radio-telemetry, and determine home range size. Often the overall objective is to know how many animals are present in a much larger area, such as a region or province. However, studies on low density species must be interpreted cautiously because low sample sizes are common, despite the expense and effort invested to study terrestrial carnivores. As a result, such intensive studies are few, or have not been conducted at all. Thus, confidence limits cannot be attached and results can only be extrapolated to areas which are ecologically similar, and not outside of the ecoprovince.

Limits to time and money are major constraints to the application of capture–telemetry of medium carnivores in British Columbia. Due to the difficulty in studying these species, the lack of information on habitat relationships and life-history, and the effort involved in trapping and collaring animals, both population and habitat questions should be addressed in studies that use capture–telemetry methods. Determining absolute abundance will rarely be the primary justification in conducting such studies.

Ethical methods and proper animal care are major considerations in a live-capture study (consult the manuals *Wildlife Radio-telemetry* (*No. 5)* and *Live Animal Capture and Handling of Wild Mammals, Birds, Amphibians and Reptiles* (*No. 3*)). As there is no guarantee that animals in this inventory group can be re-captured, collars should be equipped with a break-away section that rots, leaving the collar to eventually drop. Similarly, collars cannot be used on young animals who are still growing. Species such as wolverine are also very rough on traditional collars and can lose them. An alternative method, radio-transmitter implants, are being used successfully with wolverine in the province (J. Krebs and E. Lofroth, pers. comm.) They may be a suitable choice for all members of this inventory group. Due to morphology, only implants can be used on badgers. Radio-implants can only be inserted by a qualified veterinarian.

Two other systems should be mentioned, satellite collars and GPS collars. For both, locations are automatically recorded when the animal is in the open and a tracking satellite passes overhead. For GPS collars, locations are recorded continuously as long as the transmitter, i.e., the collar, has access to satellites (Rodgers *et al.* 1996). The accuracy of the latter can be very good, within centimeters, if a base station simultaneously collects location information and locations can be differentially corrected. For satellite collars, location errors can be as large as one km or more.

For both systems, animals must regularly be in the open so that locations can be obtained. This will not be the case for this inventory group in most of the province. Also, satellite telemetry has, in general, not been tested on animals smaller than bears and ungulates. Kennedy *et al.* (1998) attempted to use satellite transmitters for monitoring the movements of coyotes and concluded that the technique had limited applicability for species using forest cover. John Lee (pers. comm.) experimented with two satellite collars for wolverine on the barrens of the Northwest Territories. Although the collars worked fine on captive animals, no locations were obtained once collars were placed on wild wolverines.

Office Procedures

- Review the introductory manual, *Species Inventory Fundamentals* (*No.1).*

- Obtain appropriate maps at a variety of scales. Topographic maps at 1:50,000 and 1:250,000 are best for navigating by air while maps and air photos at 1:15,000 and 1:20,000 are best for recording locations.

Sampling Design

- The first task is selection of an appropriate Study Area. For wolverine, a suitable Study Area will be in the range of 5,000 to 10,000 km^2 and even then, large sample sizes of adult residents will not be forthcoming considering an adult male's home range can be 1000 km^2. Study Areas for telemetry studies of bobcat and badger must also be large, in the range of 2000 km^2 or larger. For fisher and lynx, Study Areas of 1000 km^2 should yield a sufficient number of individuals.
- Because these species are relatively rare the objective should be to capture all residents present in the Study Area in order to reach a sufficient sample size. Although this is possible, it is unlikely. Extremely trap-shy animals are very difficult to trap and the study population may be underestimated. Individuals known to be present in the area by their sign but cannot be captured are added to the study population estimate. The error of adding or ignoring non-captured individuals is small if the sample of collared animals is large enough. However, the error of not including these individuals is large if the sample is small and not representative of all resident home range sizes.
- Although attempts should be made to cover the Study Area during trapping without any large gaps, traps should be biased to the best habitats and to travel routes, as discussed for the placement of bait/scent stations (Section 3.4.2). Take advantage of accumulations of food such as spawned salmon or road kills. All of these species will eat carrion, including lynx if they are hungry. The presence of human activity may or may not be a factor. In central B.C., wolverine were trapped in forested corridors adjacent to busy logging roads (E. Lofroth, pers. comm.) while in the East Kootenay, females were generally not trapped until researchers accessed the back-country (J. Krebs, pers. comm.).
- Cameras and hair snares can be useful additions to trap sites as they can provide information on animals attracted to the trap site but too wary to enter the trap.

Sampling Effort

- Expect low trapping success for low density populations. Intensive trapping of wolverine has yielded 1 animal for about 30 trap nights. Maximize the number of traps and their distribution in the landscape. Expect to continue trapping for a minimum of three winters to capture all resident adults. Allow at least one extra year to account for uncontrollable events, such as extreme weather, or the need to change the trapping system.
- Plan to track animals for several years, or as long as collars continue to transmit and are affixed to the animals. At least 2 years of complete data per individual are needed to determine home range size, to account for seasonal and annual differences. Animals should be re-located as often as possible, but at least once a week.

Personnel

- Persons should be trained in the trapping and care of immobilized animals, and in radio-telemetry procedures. The provincial immobilization course is obligatory.

- A veterinarian is required if implants are being used. Not all veterinarians are qualified to work with wildlife species. Consult the Ministry of Environment.

Equipment

- A variety of live-traps, sold under a number of trade names (Tomahawk®, Havahart®), are available for medium carnivores. These are all in the form of steel mesh box traps.
- The use of leg-holds, whether padded or modified, are not recommended for these species.
- For wolverine in forested habitat, the best trap appears to be a log cubby built on site (Copeland *et al.* 1995). This trap may also be suitable for some of the other species in the inventory group.
- Traps can be equipped with remote transmitters to indicate when a trap has been triggered, to facilitate monitoring and reduce disturbance (Copeland 1996). These are available from manufacturers of radio-telemetry equipment.
- Appropriate drugs and immobilizing equipment.
- Appropriate bait and scent, as described for bait/scent stations.
- Radio-telemetry equipment: collars or implants, appropriate tools for attaching collars, receiver, ear-tags.
- Cameras and hair snares, if these are to be deployed at trap sites (Section 3.4.2).
- Aircraft charter, usually airplane, for relocations.
- GPS receiver, for recording locations.
- Computer and statistical analysis software.

Field Procedures

The successful trapping of carnivores is a function of understanding animal behaviour and of the “personality” of the animals within the population being trapped. Some of these species are easy to trap, such as fisher, others are more difficult (lynx during hare population highs). Some populations within the same species may be easier to trap than others. Wolverine inhabiting an area with much human activity (especially trapping) may be vary wary of steel box traps while wolverine in more pristine areas may not have the same behaviour. Canids and felids are typically wary of human scent, unless very hungry, while mustelids may even be attracted by human scent. Consult researchers who have live-trapped the target species and with local trappers in your area. Be prepared to change trapping methods and sampling design, if these are not successful.

- Survey the Study Area and identify access routes prior to the start of the winter trapping season. If on-site log traps are to be used, these can be built in the summer or fall. Clear snowmobile trails of debris and establish field camps. Trapping is intensive and time-consuming thus complete as much field preparation as possible prior to the winter.
- Begin trapping as soon as the snow falls. Place traps in selected locations. Ensure traps are protected from rain, wind and falling snow. Provide sufficient bedding material in the form of straw; this is especially critical for metal traps. Use pre-bait and scent. Researchers have towed a piece of rotten carcass or pelt behind a snowmachine on the trail leading to the trap to attract animals.

- Cameras and hair snares can be useful as they may indicate if an animal is in the area but too shy to enter the trap.
- Animals will not move when temperatures are very cold, and equipment has a greater tendency to malfunction. For humane reasons, it is generally a good idea not too trap if tempertatures are extreme.
- Check live-traps daily. Traps can be equipped with remote transmitters which are intended to send out a signal when the trap is sprung. These traps may only need checking once every three days to ensure that the trigger mechanism has not frozen, that the door closes completely and hasn't been blocked by falling snow or debris, and that sufficient bait still remains. Check traps daily if there is any doubt as to the reliability of the "tripped" signal.
- Handle live-trapped animals quickly and quietly to minimize stress, as indicated in *Live Animal Capture and Handling of Wild Mammals, Birds, Amphibians and Reptiles* (*No. 3*)). Release non-target species immediately.
- Locate the animal for the next two successive days to ensure it has recovered from the tagging process and that the transmitter is functional. Subsequently, locate animals preferably once a week, or more frequently, and at most, biweekly.
- Animals may be re-located by vehicle, on foot or horseback. For most of these species, especially where access is difficult, aircraft will the most efficient means of obtaining locations.
- The trapping season should terminate in the spring, before black and grizzly bears are active.

Data Analysis

The boundaries of the Study Area is usually larger than the area trapped; it is fixed as the area which encloses locations of all residents, except outlying locations. Territorial carnivores occasionally make excursions outside of their home ranges which are temporary and outside of their usual range. These are excluded in calculations of density. For species with stable home ranges, the density estimate is an absolute reflection of the number of animals the area can support.

Calculate the absolute density of the Study Area as km^2 per resident adult (include both males and females). Densities should be calculated for the fall period, after juvenile dispersal but before winter mortality. If information on juvenile and transient animals are available, a density estimate including these segments of the population should also be calculated. How these estimates were derived should be explicitly stated.

Report the average home range size (+/- 95% confidence level) for adult males and adult females. If sufficient information on juveniles and transients is available to calculate home ranges, these should also be reported. However, the density estimate is based on those resident adults which maintain stable territories.

A variety of techniques and software are available to evaluate home range sizes. Minimum convex polygon (MCP) home ranges are a standard statistic computed by most researchers and allow comparison between areas. However, when all points are included, the MCP does not indicate how intensively different parts of the home range are used, although smaller polygons (i.e., 90%, 75% 50% MCPs) can be calculated.

Two other common methods of calculating home ranges, adaptive kernel (ADK) and harmonic mean (HM) estimators (Boulanger and White 1990), allow determination of more than one center of activity or core-activity area (Dixon and Chapman 1980, Worton 1995, Harris *et al.* 1990). These are generally superior to MCP as long as there are criteria established for the selection of level of home range to be used. The harmonic mean estimator has often been criticized as being too strongly dependent on grid spacing and scale (Worton 1995 and others). Lawson and Rodgers (1997) reviewed home range programs and reported that widely varying results could be produced, largely dependent on the results of user decisions with respect to calculations of estimators and various parameters. It is recommended that project biologists calculate both MCP and ADK home ranges, and reporting not only the estimator and home-range program used but also the values of input parameters and user-selected options (Lawson and Rodgers 1997).

3.6.2 DNA Mark–Recapture

This technique is under investigation and is not recommended for current use to estimate absolute abundance.

The DNA mark–recapture technique is under investigation for bear population estimation in British Columbia (see manual no. 21, *Inventory Methods for Bears*) and for wolverine (J. Krebs, E. Lofroth, pers. comm.). Recent developments in DNA fingerprinting techniques (microsatellites) has allowed the use of DNA identification as a marker for individual bears and wolverines (Chris Kyle pers. comm.). Microsatellites are highly polymorphic genetic markers which provide rich information about genetic background, including the identification of individuals. These markers are usually species-specific, necessitating the development of new assays for each species, which can be costly and time consuming. Markers have been developed for many forest carnivores (Foran *et al.* 1997b) and considerable research is ongoing.

The main benefits of the DNA mark–recapture technique are 1) animals do not have to be captured to be marked, therefore, they are not handled or disturbed, 2) marks cannot be lost, 3) relatively large sample sizes can be obtained, at least with bears, and 4) individuals can be identified with little error. However, there are many sampling biases that potentially may violate the assumptions of mark-recapture.

Biases which may affect DNA-based estimates of abundance are similar to those from other carnivore surveys where capture is involved. Carnivores are baited to investigate a hair snare, which essentially functions as a “trap”. Individuals are not equal in their catchability due to sex, age, their hunger level and their prior experience with traps, among other factors. It is difficult to identify a geographically closed population during DNA sampling for any of these species except the very rare badger. Because of the behaviour and spatial patterns of territorial carnivores, sampling cannot likely occur over a short enough period to ensure that the survey population is closed while still capturing an adequate proportion of the total number of individuals.

DNA mark-recapture is included as a potential method with the recommendation that it deserves further study. Studies involving capture of animals should collect hairs and include a DNA component to investigate the utility of this technique.

Glossary

ABSOLUTE ABUNDANCE: The total number of organisms in an area. Usually reported as absolute density: the number of organisms per unit area or volume.

ALLOTOPIC: Adjective to describe sympatric populations whose geographical ranges overlap even though each population occurs in different habitats within that range.

BLUE LIST: Includes any indigenous species or subspecies (taxa) considered to be Vulnerable in British Columbia. Vulnerable taxa are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed taxa are at risk, but are not extirpated, endangered or threatened.

BIODIVERSITY: Jargon for biological diversity: the variety of life forms, the ecological roles they perform, and the genetic diversity they contain (Wilcox 1984 cited in Murphy 1988).

CANID: A carnivore belonging to the family Canidae (dogs).

CRICETID: A small mammal belonging to the family Cricetidae (mice and voles).

CUTICULAR PATTERN: The pattern that the overlapping scales or cuticles made by the external surface of a guard hair. This pattern is species specific.

FAS: Fatty Acid Scent.

FELID: A carnivore belonging to the family Felidae (cats).

GPS: Global Positioning System.

GRID CELL: A rectangular cell, generally occurring within a larger, rectangular, multi-celled grid. Grid Cells provide a basis for distributing sampling devices, such as scent/bait stations, cameras and/or transects, across the landscape. They are also the primary sample unit for many surveys.

LEPORID: A mammal belonging to the family Leporidae (rabbits and hares).

LINE: A string of stations, set up at intervals along transects or in a grid patterns.

LTD: Latency To Detection.

MICROSATELLITE: A gene marker used in genetic (DNA) analyses.

MUSTELID: A carnivore belonging to the family Mustelidae (weasels and allies).

PRESENCE/NOT DETECTED (POSSIBLE): A survey intensity that verifies that a species is present in an area or states that it was not detected (thus not likely to be in the area, but still a possibility).

PROJECT AREA: An area, usually politically or economically determined, for which an inventory project is initiated. A project boundary may be shared by multiple types of resource and/or species inventory. Sampling generally takes place within smaller Study Areas within this Project Area.

RANDOM SAMPLE: A sample that has been selected by a random process, generally by reference to a table of random numbers.

RED LIST: Includes any indigenous species or subspecies (taxa) considered to be Extirpated, Endangered, or Threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations.

RESIDENT: Among territorial carnivores, an individual animal that occupies and remains on a more or less exclusive home range (territory) for more than one season.

RELATIVE ABUNDANCE: The number of organisms at one location or time relative to the number of organisms at another location or time. Generally reported as an index of abundance.

SCAT: A single deposit of feces.

SCIURID: A rodent belonging to the family Sciuridae (squirrels)

STRATIFICATION: The separation of a sample population into non-overlapping groups based on a habitat or population characteristic that can be divided into multiple levels. Groups are homogeneous within, but distinct from, other strata.

STUDY AREA: A discrete area within a project boundary in which sampling actually takes place. Study Areas should be delineated to logically group samples together, generally based on habitat or population stratification and/or logistical concerns.

SURVEY: The application of one RIC method to one taxanomic group for one season.

SYMPATRIC: Adjective to describe two or more populations whose geographical ranges or distributions overlap.

SYSTEMATIC SAMPLE: a sample obtained by randomly selecting a point to start, and then repeating sampling at a set distance or time thereafter.

TRANSIENT: Among territorial carnivores, an individual that does not occupy or reside on an exclusive home range or territory ("of no fixed address").

YELLOW-LIST: Includes any native species which is not red- or blue-listed.

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Appendix A. Ecoprovinces and corresponding Management Units (MU's)

Note: This can be a useful aid in interpreting the provincial trapper survey for a particular trapline. Each trapline number contains the number of the MU in which it occurs, and, thus, this appendix may be used to identify the Ecoprovince in which a trapline occurs. For example, trapline number 0103P101 occurs in MU 103, and MU 103 occurs in the Georgia Depression ecoprovince.

Ecoprovince	Management Units
Georgia Depression	101, 102, 104, 105, 106, 204
Coast and Mountains	103, 107, 108, 109, 110, 111, 112, 113, 114, 115, 202, 203, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 314, 507, 508, 509, 603, 610, 611, 612, 613, 614, 615, 616, 621
Southern Interior	312, 313, 315, 316, 317, 318, 319, 320, 326, 327, 328, 329,
Central Interior	330, 331, 332, 333, 501, 502, 503, 504, 505, 506, 510, 511, 512, 513, 514, 601, 602, 604, 609, 711, 712
South Interior Mountains	334, 335, 336, 337, 340, 341, 342, 343, 344, 345, 346, 401, 402, 403, 404, 405, 406, 407, 408, 409, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 515, 516, 701, 702, 703, 704, 705, 706, 707, 813, 814, 815, 823, 824, 825
Southern Interior	338, 339, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 821, 822, 826
Sub Boreal Interior	605, 606, 607, 608, 617, 618, 630, 708, 709, 710, 713, 714, 715, 716, 717, 718, 719, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 736, 737, 738, 743
North Boreal Mountains	619, 620, 622, 623, 624, 625, 626, 627, 628, 629, 739, 740, 741, 742, 750, 751, 752, 753
Boreal Plains	720, 732, 733, 734, 735, 744, 745, 746
Taiga Plains	747, 748, 749, 754, 755, 756