Inventory Methods for Marten and Weasels

Standards for Components of British Columbia's Biodiversity No. 24

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Preface

This manual presents standard methods for inventory of martens and weasels 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 groups 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 wildlife 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 wildlife 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 wildlife inventory. Survey-specific data forms accompany most manuals while general wildlife inventory forms are available in the 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/ric_manuals/

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”.

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All decisions regarding protocols and standards are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this version are based on substantial contributions from Mark A. Fraker. In addition, Mark A. Fraker, William J. Gazey, and Virgil C. Hawkes contributed to an earlier unpublished draft, *A Preliminary Inventory Manual for Martens and Weasels in British Columbia*, with valuable comments, reviews and/or assistance from Drs. Martin Raphael (US Forest Service) and Richard Golightly (Humboldt State University), Eric Lofroth (BC Wildlife Branch), Kathy Neer (MOELP Head Librarian) and her staff. John Boulanger provided comments on mark-recapture design and analysis.

This manual and its associated dataforms were edited to their final forms by James Quayle and Leah Westereng.

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1. Introduction

This manual provides standard inventory methods to determine distribution and abundance in British Columbia of the species listed in Table 1 below.

Table 1. Species of interest, including Latin names and their codes.

Species	**Latin name**	**Code**
Marten	*Martes americana*	M-MAAM
Ermine or Short-tailed weasel	*Mustela erminea*	M-MUER
Long-tailed weasel	*Mustela frenata*	M-MUFR
Least weasel	*Mustela nivalis*	M-MUNI

Techniques for inventory of these species are in a period of rapid development and testing. Thus, the protocols presented here are a first step in developing standard methods for British Columbia.

The inventory techniques described are based to a large extent on the substantial amount of recent work in the Northwest U.S. funded largely by the U.S. Forest Service in response to concerns about the effects of forest harvest and management practices on marten, fisher, wolverine, and lynx. Most of the work, therefore, is particularly applicable to martens (and fishers), while weasels have received very little attention. Conceptually, the techniques that apply to martens should also apply to weasels, with the primary differences being scale.

2. INVENTORY GROUP

2.1 American martens *(Martes americana)* M-MAAM

2.1.1 Ecology and habitat requirements

The American marten is a long, slender-bodied animal about the size of a mink with relatively large, rounded ears, short limbs, and a bushy tail, with considerable individual variation in coat colour (Clark *et al.* 1987). The long, silky, dense fur ranges in colour from pale yellowish buff to tawny brown to almost black (Clark *et al.* 1987). Individual martens have multiple markings that vary in size, location, and colour. Most martens are a tawny – brown with a darker chest and lighter belly. Martens are medium-sized members of the weasel family, weighing from 500 to 2000 g as adults depending on sex and region (Clark *et al.* 1987). Sexual dimorphism is pronounced, with males averaging about 15% larger than females in body length and as much as 65% larger than females in body weight (Clark *et al.* 1987). Other than differences in size, males and females are similar in appearance (Clark *et al.* 1987, Lofroth and Banci 1991, Buskirk and Ruggiero 1994).

Martens are opportunistic feeders. Their diets vary by season, year, and geographic area, according to the availability of different foods (Buskirk and Ruggiero 1994). In summer their diet can include birds' eggs and nestlings, insects, fish, and young mammals, while in fall, berries and other fruits are more important (Strickland and Douglas 1987, Buskirk and Ruggiero 1994). Several studies have shown that arvicoline rodents, especially *Clethrionomys* spp. and *Microtus* spp., are the major food of martens, particularly in fall and winter (Strickland and Douglas 1987). Snowshoe hares can be important and there is some evidence from fur harvest studies that marten populations may shadow snowshoe hare population fluctuations (Clark *et al.* 1987, Strickland and Douglas 1987). Winter food sources are primarily made up of carrion and larger prey items such as snowshoe hares, grouse, and squirrels (Strickland and Douglas 1987).

Martens occupy a variety of habitat types, living in or near coniferous or mixed-wood forests (Allen 1987, Chapin *et al.* 1997). In British Columbia, martens use habitats of many structural stages, from young seral to old-growth (Anon. 1996). However, during winter, they do not use certain structural stages, including 1a (less than 10% vegetation cover), 1b (bryophyte and lichen-dominated communities), 2 (herb dominated communities), 3a (low shrub communities), and 3b (tall shrub communities) (Anon. 1996). Most habitat use, especially resting and maternal denning, is associated with forest structural classes 6 (mature) and 7 (old) (Strickland *et al.* 1982, Lofroth and Banci 1991, Lofroth 1993, Buskirk and Ruggiero 1994). Marten foraging behaviour and thermal needs during winter impose special habitat requirements that must be met by structural features of forests. In particular, they are dependent on 30 - 80% canopy closure, abundant coarse woody debris (CWD), and wildlife trees (snags and trees with broken tops in decay classes 2 - 6 (Chapin *et al.* 1997, Krohn *et al.* 1997). Optimum habitat elements appear to be found in mature old-growth with a well established understory of coarse woody debris (CWD), which can include stumps and fallen logs (Clark *et al*, 1987). In addition to CWD, lush shrub and forb vegetation can also be components. Martens make little use of open clearings, but may use riparian areas, meadows, and forest edges (Spencer *et al.* 1983).

Key features of suitable habitat are the availability of CWD and a forest structure that can support arvicoline and sciurid prey (Burnett 1981, Lofroth and Banci 1991). Access to subnivean (beneath the snow) areas is important for finding prey and for thermoregulation during winter. Therefore, if access to subnivean areas is limited, as in the case of clearcuts, martens densities may be limited more by the loss of valuable hunting habitat, rather than by densities of prey (Strickland and Douglas 1987). In the absence of deep snow, martens forage in a wider range of structural stages and habitat use may be further influenced by population cycles of major prey species. Martens will use younger seral stages providing specific habitat needs are met. Specifically, if prey and cover are abundant, martens will use areas that are not mature or old growth forests. However, in younger forests, martens may have larger home ranges and lower population densities (Soutiere 1979, Strickland and Douglas 1987, Lofroth and Banci 1991). In the Pacific Northwest, mature forests with 30 - 80% crown cover generally support a higher density of martens than do forests with < 30% crown cover (Clark *et al.* 1987, Lofroth 1993). However, Chapin *et al.* (1997) found that martens in Maine regularly selected habitats with less than 30% canopy closure, and that habitat selection was based primarily on the abundance of CWD. These conflicting results suggest that within different regions, the various physical characteristics of a given habitat will influence marten distribution to different degrees.

Snow depth can influence the distribution of martens in a given area. Krohn *et al.* (1997) found that martens were associated with areas of greater snowfall (>23 cm per winter month) than were their close relatives, fishers (*Martes pennanti*) (< 13 cm per winter month). Krohn *et al.* (1995) stated that high fisher populations might limit marten populations through interspecific competition. Also, marten distribution may be influenced by the fact that fishers sometimes prey on martens (Foresman pers. comm.; Weir pers. comm.). Because of their large foot size relative to body weight, martens are less affected by soft snow than are fishers (Clark *et al.* 1987). Like fishers, martens are averse of vegetation types lacking overhead cover, probably due to their exposure to avian predators (Clark *et al.* 1987, Buskirk and Ruggiero 1994).

During inclement weather, martens may remain in dens. Resting sites and dens have been found in hollows in trees or large branches, in hollow logs and stumps, in ground burrows, rock piles, crevices, excavations at the roots of trees, or on brushy slopes (Clark *et al.* 1987). Winter or thermal resting sites have been found beneath the snow in natural cavities, under stumps and snags, and in bulldozed debris (Clark *et al.* 1987)

Male and female martens have separate home ranges, with the home range of one male overlapping that of several females (Clark *et al.* 1987). Spacing systems of female martens appears more rigid than those of males (Phillips *et al.* 1998). In untrapped populations, female martens may abandon their home range due to stress associated with high population densities (Phillips *et al.* 1998)

Martens are generally solitary seeking out others only during breeding season, when temporary pairings occur (Clark *et al.* 1987, Strickland and Douglas 1987) and when females raise young (Strickland and Douglas 1987). Breeding takes place from late June to early September, with most mating in July (Buskirk and Ruggiero 1994). Female martens generally breed for the first time at 15 months of age, producing their first litter around 24 months of age (Strickland and Douglas 1987). Male martens are sexually mature around 15 months, though there is some doubt as to whether or not a 15 month old male martens, even if spermatic, could breed as effectively as older males (Strickland and Douglas 1987).

Courtship may last 15 days and is characterized by much playing and wrestling (Clark *et al.* 1987).

Copulation occurs on the ground or in trees. The male typically seizes the female by the neck and drags her around prior to copulation, which is prolonged (up to 120 minutes) (Clark *et al.* 1987, Buskirk and Ruggiero 1994). The lengthy copulation appears to induce ovulation. If the female marten does not conceive at first mating, she will become receptive again one to two weeks later (Strickland and Douglas 1987). It is unclear whether female martens undergo a single long estrus, or multiple brief estruses in the wild. Like other mustelids, delayed implantation occurs seven to eight months after mating, and appears to be controlled by environmental and physiological factors (Clark *et al.* 1987), with an active gestation of only 27 days (Strickland and Douglas 1987, Buskirk and Ruggiero 1994).

As with most other mustelids, embryonic development remains at the blastocyst stage with resumption of further development under photoperiodic control (Buskirk and Ruggiero 1994). Young martens are born in a den often located in a hollow tree or log, or rock cavity (Clark *et al.* 1987). Average litter size is estimated at three kits (with a range of one to five), based on examination of the corpora lutea; actual living litter size is not well documented (Strickland and Douglas 1987). Kits open their eyes at around 35 days of age and are weaned at around 42 days. At around 50 days, young martens emerge from the den, but may still be moved to other dens by the mother (Buskirk and Ruggiero 1994). Young will travel with the mother until the family group disperses in late summer or early fall (Clark *et al.* 1987).

Like other mustelids (*e.g.*, fisher and wolverine (*Gulo gulo*)) male martens do not assist in rearing young; however, they may exclude other males from their territory resulting in foraging opportunities for females and juveniles resident within the area (Clark *et al.* 1987). Maternal care involves selecting a suitable den, carrying nest material to the den, moving kits from den to den, and bringing food to the young until they are old enough to forage for themselves (Buskirk and Ruggiero 1994). The availability of trees suitable for natal and maternal denning is critical to successful reproduction. Although martens may den in trees as small as 25 cm dbh, Lofroth and Banci (1991) recommend that management plans provide for a continuing supply of trees of decay class two and of ≥ 40 cm dbh.

2.1.2 Distribution and status

Species Range

Historically, the American marten occurred from Alaska across most of Canada, New England, the Alleghenies, the Great Lakes region, the Rocky Mountains south to New Mexico, the Sierra Nevadas, and the Cascades. It still occurs across most of its range, but has been extirpated from many southern areas, including southern Ontario, southern Quebec, and Prince Edward Island (Clark *et al.* 1987). The marten has undergone range contractions and expansions thought to be related to extensive logging of late successional stage forests and their subsequent regrowth (Thompson and Harestad 1994).

Provincial Range

Martens are found throughout British Columbia, including the coastal regions and most islands (Cowan and Guiguet 1965).

Status

Martens are a regionally significant species and all four subspecies appear on the provincial "Yellow List". Martens are managed as Class 1 furbearers and are legally harvested for their pelts. Martens are classed as *threatened* in Newfoundland by COSEWIC, *protected* in Utah, and *endangered* in New Mexico. The marten is designated as an *ecological indicator species, high interest species*, or *sensitive species* in many US National Forests.

2.1.3 Density patterns

As with other mustelids, home ranges of adult male martens typically overlap those of several females (Strickland and Douglas 1987). Powell (1994) went on to state that, in addition to sex-related size differences, there is a positive correlation between body size and home range size. Home ranges vary in size according to season, sex, age class, and prey abundance (Table 2; Buskirk and Ruggiero 1994).

There are several possible explanations as to why male home ranges are larger than those of females. First, males may have energy requirements greater than expected from body size alone, and therefore need disproportionately larger home ranges. Male martens exhibit intrasexual territoriality, where individuals maintain territories only with respect to members of the same sex. Second, the actual area used and defended by males and females may be proportional to body size, although the total home range is not. Third, males and females may space themselves differently to gain access to different resources: females may primarily require access to food, while males may require a greater access to both food and females (Powell 1994).

As the young of the year leave the company of their mothers in the fall, the apparent density of martens reaches its annual peak, when there may be as many as 1.2 - 1.9 martens / km^2 (Clark *et al.* 1987). Density estimates over the entire species distribution ranges from 0.4 to 2.4 martens / km^2. In Ontario, Thompson (1994) found that densities of martens were greater in uncut than in logged forests (0.8 - 1.0 / km^2 and 0.8 - 0.2 / km^2, respectively). Within British Columbia, densities vary considerably even within biogeoclimatic zones depending on ecological conditions, prey abundance, and extent of recent forest harvesting (Buskirk and Powell 1994). For example in the wet SBS (Sub-boreal Spruce) Lofroth (1993) found a mean density of 1.4 / km^2 while in the CWH (Coastal Western Hemlock) a mean density of 1.2 / km^2 was found.

Marten populations may be regulated by food (Clark *et al.* 1987). Within a given year, the densities of independent animals will be greatest just after weaning, and lowest in the late winter or early spring (owing to dispersal and mortality) when prey densities are also lowest. Because the populations of many prey species are cyclic, there are also among year changes in density. When attempting to survey marten populations for absolute numbers, the most appropriate time to sample would be in late winter and early spring (which will vary slightly depending on location), when the population is at its annual minimum and more indicative of carrying capacity. Late winter and early spring is also the best time for determining presence in various habitat types because, in contrast to fall, dispersing animals are less likely to be present in marginal habitats. Furthermore, a given weasel population can expand and contract from one year to the next as a result of a fluctuating prey base, extremes in climate, and changes in predator abundance.

Table 2. Estimates of marten home range sizes (After Powell 1994, Phillips *et al.* 1998).

Geographical Area	Habitat	Home Range Size (km^2)		m:f
		males	females	
Vancouver Island, BC, Canada		4.8	2.3	2.1
Newfoundland, Canada			2.3	2.1
Alaska, USA		7.1	7.9	0.9
Ontario, Canada	old forest, abundant prey	3.4	1.0	3.4
Ontario, Canada	old forest, scarce prey	6.8	4.2	1.6
Ontario, Canada	cut forest, abundant prey	5.0	3.1	1.6
Ontario, Canada	cut forest, scarce prey		13	0.8
Northwest Territories, Canada		10	4.3	2.3
Northwest Territories, Canada		6.1	1.9	3.2
Yukon Territory, Canada		7.1	5.6	1.3
Yukon Territory, Canada		8.7	6.6	1.3
New York, USA Baxter State Park, Maine	Mature closed-canopy stands (>50%); 70-120 yr. Old; abundant prey	4.6 2.4	2.4 1.9	1.9 1.3

2.1.4 Activity patterns

Daily activity patterns appear to vary with geographical region. Zielinski *et al.* (1983) found that martens in California were most active at night during winter, but at midday during summer. Thompson (1986) did not find that marten activity corresponded to the activity periods of major prey species in Ontario; however, activity occurred during the warmest part of the day during winter. Martens may remain inactive during storms and periods of extreme cold (Clark *et al.* 1987, Hawkes pers. obs.). Martens are active year round and do not hibernate. Dispersal movements, involving unidirectional movements by many animals, have been reported by trappers in Alaska and elsewhere, but have not been documented in the scientific literature (Buskirk and Ruggiero 1994).

2.1.5 Conspicuousness and distinctiveness of sign

The identification of tracks, even during favourable conditions, may be unreliable. Marten and fisher territories often overlap, leading to possible confusion. At some times of the year, even when snow is on the ground, crusts, freezing and thawing, etc. can create unfavourable conditions for tracking, and these may vary according to time of day, slope, and aspect (Halfpenny *et al.* 1995). Tracks left by male martens may be difficult to distinguish from those left by female fishers (Zielinski and Truex 1995). In fact, Halfpenny and Biesiot (1986) give an account for marten and fisher tracks based solely on those left by martens. Certain qualitative traits, such as the shape and connectiveness of palm components, hairiness of the track, and absence of particular toe pad impressions may help differentiate martens and fisher, given ideal conditions and high quality track images, but exceptions to these traits are not uncommon (Zielinski and Truex 1995). Zielinski and Truex (1995) developed a discriminate function that discriminates between tracks of adult martens and fishers. Measurements of images left on track plates, from which accurate measurements of each track can be made and defining characteristics can be noted are used to distinguish between marten and fisher. Other measurements, such as stride and straddle may provide supplemental, but non-definitive information (Halfpenny *et al.* 1995). Unless the track is fresh and easily distinguished from all other possibilities, and there is another defining character relating to marten it should be discounted and no attempt should be made to include a set of questionable tracks in any survey. To be 100% certain, track plates and the discriminate function developed by Zielinski and Truex (1995) must be used. Again, late winter and early spring are the best times to conduct surveys because young fishers and martens will have reached adult size, minimizing the overlap in paw print size.

Mustelids generally have latrine sites at or near their dens. However, without knowing the location of a den, there is no reliable way to find them. Therefore, the identification of latrine sites, as can be done with river otters, can not reliably be used as a method to ascertain whether martens are using an area. Furthermore, marten feces may be difficult to distinguish from other mustelids of similar size (*i.e.*, fisher), especially when dietary composition is also similar.

In the event that snow-tracking is being used as the primary survey method, locations where possible fisher tracks are seen should be verified using Automatically Triggered Cameras (ATC's) or Covered Track Plates (CTP's).

2.2 Weasels

Long-tailed weasel *(Mustela frenata)* M-MUFR, Ermine *(Mustela erminea)* M-MUER, and the Least weasel *(Mustela nivalis)* M-MUNI

2.2.1 General ecology and habitat requirements

Much of the following description is based on Fagerstone (1987) who provides an excellent description of the natural history of the weasel. Weasels are the smallest members of the order Carnivora, often weighing much less than one kilogram. They have long slender bodies with short legs. All have five toes with sharp, non-retractile claws. The long, slender body shape is believed to be an evolutionary adaptation to underground pursuit of prey. As with martens, male weasels are larger than females, weighing more than twice as much. Size differences have been related to exploitation of different sized prey, thus reducing intraspecific competition with one another when food is scarce. Another theory deals with the promiscuity of male weasels. Their large size may be advantageous during competition with other males for access to females, and when defending large territories that often include more than one female.

Weasels kill a variety of animals, many much larger than themselves. Their slender bodies enable them to pass through any burrow they can get their head through, making them efficient predators of burrowing rodents. Weasels are terrestrial hunters preying on small rodents, birds, rabbits (*Sylvilagus* spp.), or other animals that are locally available. Weasels hunt primarily underground or under snow, and are active day and night. To compensate for proportionately greater heat loss created by a high surface area: body volume ratio resulting from their elongate shape, weasels have a higher metabolic rate than other mammals their size.

The home ranges of male and female weasels overlap, with the home range of one male overlapping those of several females. Weasels are generally solitary except during breeding season and when females raise young. Densities of weasel populations will vary throughout the year, with the highest densities occurring post parturition. The highest apparent density, however, occurs after weaning when the young-of-the-year become independent. Afterwards, the population then declines due to high mortality and dispersal of juveniles. Furthermore, a given weasel population can expand and contract from one year to the next as a result of a fluctuating prey base, extremes in climate, and changes in predator abundance.

During mating season, temporary pairings occur. The male typically seizes the female by the neck and drags her around prior to the prolonged copulation, which can last one to two hours. It is believed, that like martens, weasels are induced ovulators, and the lengthy copulation induces ovulation (Wright 1942a). In least weasels *(Mustela nivalis)*, as in most other mammals, the fertilized egg develops into a blastocyst, travels to the uterus, and implants. Conversely, with the ermine or short-tailed (*Mustela erminea)* and long-tailed *(Mustela frenata)* weasels, implantation is delayed and appears to be under specific environmental and physiological control, such as photoperiod and hormonal fluctuations. Young weasels are born blind and open their eyes at three to six weeks depending on the species. Young nurse for six to twelve weeks and remain with the mother for only about one week after weaning. A high mortality rate (usually > 50%) occurs during the first year in most species.

Tables 3 and 4 provide summary information about weasel home range sizes and density. More detail about density patterns is provided under the natural history sections for each species.

Table 3. Estimates of weasel home range sizes (After King 1990).

Species	**Geographical Area**	**Habitat**	**Sex**	**Size (km^2)**	**m:f***
Ermine or Short-tailed weasel *Mustela erminea*	Scotland	farmland	m f	2.54 1.14	2.23
	Sweden		m f	0.08-0.13 0.02-0.07	2.33
	Ontario, Canada	mixed forest**	m f	0.20-0.25 0.10-0.15	1.80
	Switzerland	alpine	m f	0.08-0.40 0.02-0.07	5.33
	Finland	mixed forest	m f	0.29-0.40 0.04-0.17	3.29
Long-tailed weasel *Mustela frenata*	Michigan, USA	mixed forest	m+f	0.32-1.60	
	Colorado, USA	mixed forest	m+f	0.80-1.20	
	Kentucky, USA	farmland	m	0.06-0.24	
	Indiana, USA	mixed forest	f	0.41	
Least weasel *Mustela nivalis*	Iowa, USA	farmland	m+f	0.04-0.10	
	Finland	mixed forest	m f	0.006-0.03 0.002-0.021	

*Where King (1990) gave a range of home range sizes, the ratio of male:female home range size has been calculated using the mid-point of the range.

**Mixed forest refers to a combination deciduous / coniferous forest structure

Table 4. Densities of weasel populations (After King 1990).

Species	Geographical Area	Habitat	Density (number/km^2)
Ermine or Short-tailed weasel *Mustela erminea*	S. Sweden	rough pasture	3-10
		marshy area with abundant water voles	up to 22
	Ontario, Canada	mixed agricultural, short pasture, forest	6
		overgrown pasture and shrubby areas	10
Long-tailed weasel *Mustela frenata*	Pennsylvania, USA	scrub oak/pine forest	12
	Michigan, USA	farmland	3

2.2.2 General conspicuousness and distinctiveness of sign

Snow-tracking may not directly reflect numbers, gives no physical information about the animal, and cannot be used in summer or mild climates (King 1983). Depending on snow conditions, long-tailed weasels may not leave any distinguishable sign. Also, there is considerable habitat overlap between long-tailed weasels, ermine, and least weasels, and the largest individuals of small species may have similar tracks as the smallest individuals of a larger species. Halfpenny and Biesiot (1986) do not describe distinguishing track features for any of the weasels found in North America. Taylor and Raphael (1988) present a track measurement scheme and discuss the identification of mammal tracks from track-plates, as well as provide measurements to differentiate between the ermine and the long-tailed weasel in northwestern California. Because animal size differences may exist among different regions, it is recommended that diagnostic track-plate images be obtained using captive short-tailed and long-tailed weasels from British Columbia. The information obtained could then be compared with Taylor and Raphael. Track-plates should be used whenever possible to obtain tracks from any *Mustela* spp. The track-plate can then be compared with accurate records to identify the species to which the tracks belong.

Attempting to use scat to differentiate among weasel species will ultimately result in frustration, and will not provide useful information. However, Halfpenny and Biesiot (1986) outline the process of scatology, which may be useful if doing fecal collections at track plates, or from live traps. Simms (1979a) referred to scat of ≥ 6.0 mm in diameter as belonging to long-tailed weasels. Recent work using DNA from scat may provide a useful means of properly assigning scat to species (Foran *et al.* 1997).

Weasels have few regular habitats that offer an observer a sure ambush, and their nests are hard to find in most habitats (King 1989). King (1989) emphasizes the role of practical experience in determining the types of places one might encounter a weasel (stone walls, hedgerows, under a pile of wood or stones, in the roots of old trees, in fallen logs, and alongside streams).

Mustelids in general have latrine sites at or near their dens. However, without knowing the location of a den, there is no reliable way to seek them out. Therefore, the identification of latrine sites can not reliably be used as a method to ascertain whether or not a given weasel species is using an area.

2.3 Long-tailed Weasel *(Mustela frenata)* M-MUFR

2.3.1 Ecology and habitat requirements

The long-tailed weasel is the largest of the three North American weasels and is the least specialized (Fagerstone 1987, Sheffield and Thomas 1997). Twenty-one North American races are recognized by Hall (1981), with three subspecies in British Columbia (Nagorsen 1990). This species shows greater geographic variation in colour and size than do ermine or least weasels. In summer, its pelage is a rich brown on the back and sides with a light coloured neck and belly tinged with yellow; the tail is tipped with black (Fagerstone 1987). Weasels in the northern United States and Canada acquire a white winter coat (except for a black tail-tip). Body weights of adult male long-tailed weasels range from 160 to 450 g, and females range from 80 to 250 g (Fitzgerald 1977). As with other weasels, the long-tailed weasel exhibits sexual size dimorphism, with males being as much as twice the weight of females (Fagerstone 1987).

The long-tailed weasel has the broadest ecological and geographical range of any of the North American weasels (Fagerstone 1987). It occurs across the continent from low elevations to above tree line. Habitats occupied include forests, open woodlands, prairies, and alpine habitats, but do not include deserts (Fagerstone 1987). In British Columbia, it frequents riverbanks, lake shores, rock slides, forest edge, and prairie lands where ground squirrels, mice, pikas, and other small mammals occur (Cowan and Guiguet 1965). Also, its northern boundary in British Columbia is the transition zone between aspen parkland and the boreal forest in the central part of the province (Sheffield and Thomas 1997). Where it occurs together with the short-tailed weasel *(Mustela erminea)*, the long-tailed weasel may occupy more open habitats, whereas the ermine will occupy forested and wetland areas (Fagerstone 1987). Gamble (1981) found that long-tailed weasels preferred late seral stages or ecotones where prey species (cricetids, sciurids, leporids, and bird species) diversity was greatest. Simms (1979a) reported similar preferences for Ontario. Long-tailed weasels are apparently partially restricted to vicinity of free-standing water (Gamble 1981). Riparian zones may be important for dispersal as well as daily activities (Fagerstone 1987).

The long-tailed weasel is more of a generalist than is the ermine, and is able to switch to alternative prey when usual prey numbers are low (Simms 1979*a*; Gamble 1981, Fagerstone 1987, Sheffield and Thomas 1997). In some areas (*e.g.*, southern Ontario, Simms 1979*a*) there is > 50% dietary overlap between long-tailed weasels and ermine. Long-tailed weasels eat primarily mammals, with cottontails, chipmunks *(Tamias* spp.), and pocket gophers being major prey items. However, food habits studies and experimentation have shown that they will also consume frogs, snakes, insects, and berries (Fagerstone 1987). Ground-nesting birds and their eggs are also eaten, but constitute a small percentage of their diet (Simms 1979*a*). Voles *(Clethrionomys* spp. and *Microtus* spp.) are the most frequently selected prey, probably due to their ubiquitous occurrence (Simms 1979*a*). The diets of males and females vary with the season (Fagerstone 1987). Foxes, raptors, coyotes, martens, bob-cats, domestic dogs and cats are the primary predators of the long-tailed weasel (Sheffield and Thomas 1997). Occasionally water moccasins and rattlesnakes also prey on them.

Simms (1979a) suggested that deep snow, which may reduce forage space, and give an advantage to the ermine, limits the northern extent of the long-tailed weasel's range. Gamble (1981) on the other hand, discounted this hypothesis by citing Wobeser (1966) and Fitzgerald (1977) who claimed that long-tailed weasels are better at tunneling through snow than are ermine and do not find snow cover a barrier. Fitzgerald (1977) found that long-tailed weasels would often tunnel for several meters under snow. The weasel's long, thin shape increases its thermoregulatory costs, especially in cold climates, and snow provides vital insulation against extremes of air temperature (Chappell 1980).

Ovulation is believed to be induced by copulation (Fagerstone 1987). Delayed implantation results eight to nine months later, and active gestation from implantation to parturition takes 23 - 27 days. The female gives birth to a single litter in spring, most often in April. The number of offspring per litter ranges from four to nine, but four to five is the usual number (Fagerstone 1987, Sheffield and Thomas 1997). Reproductive output is strongly influenced by food supplies prior to parturition (Fagerstone 1987).

A detailed discussion on the reproduction of the long-tailed weasel can be found in Wright (1942a,b), or Fagerstone (1987), drawn largely from the work of Wright (1942a,b).

2.3.2 Distribution and status

Species Range

Unlike other North American weasels, the long-tailed weasel has no close Eurasian relatives (Fagerstone 1987). In North America, the long-tailed weasel occurs from southern Canada southward over most of the United States, Mexico, and Central America (Cowan and Guiguet 1965, Fagerstone 1987, Sheffield and Thomas 1997).

Provincial Range

The long-tailed weasel occurs primarily south of the regions inhabited by the ermine and the least weasel (Fagerstone 1987). Cowan and Guiguet (1965) describe three subspecies of *Mustela frenata* in British Columbia. *Mustela frenata altifrontalis* Hall is found in the extreme southwestern corner of the province, from the 121st meridian west to the coast and north to Harrison Lake. *Mustela frenata nevadensis* Hall, occurs from the Cascade range east to Kooteney Lake, and north to the 52nd parallel of latitude. *Mustela frenata oribasus* (Bangs) occupies an area that extends from Kootney lake east to the Alberta boundary, north to the 54th parallel, and west to the 125th meridian, and south and west to the vicinity of Chilko lake (Nagorsen 1990).

In British Columbia, the long-tailed weasel occurs in the Georgia Depression Ecoprovince; the S. Pacific Range, Fraser Lowland Ecosections; and in the Coastal Douglas Fir (CDF), Coastal Western Hemlock (CWH), and Mountain Hemlock (MH) Biogeoclimatic Zones.

Status

Globally, *Mustela frenata altifrontalis* is listed as 'G5T?' This indicates that the species is considered secure, with inexact numeric rank for subspecies. Provincially *M. f. altifrontalis* appears on the "Red list", which includes indigenous species or subspecies considered to be extirpated, endangered, or threatened. The current provincial ranking is 'SH', indicating that this subspecies is possibly extirpated from its historical provincial range.

The other two subspecies, *M. f. nevadensis* and *M. f. oribasus* are both on the provincial “Yellow List”.

2.3.3 Density Patterns

The following discussion of density comes primarily from Fagerstone (1987).

Home ranges are probably larger than those of the ermine and are influenced by prey availability. Home ranges of males are larger than those of females and may overlap those of several females. Males may occupy one area for their entire life, but females frequently emigrate from the natal area before establishing home ranges. When food is relatively available, males will maintain a home range of approximately 0.10 – 0.24 km^2. Where prey is not relatively abundant, males will occupy larger home ranges (0.80 –1.60 km^2). There is evidence to suggest that long-tailed weasels are not strongly territorial.

Long-tailed weasels are difficult to census due to their low densities and long distance movements. Estimates of population densities possibly vary by habitat and prey availability. Published density estimates range from 0.4 to 3.8 long-tailed weasels / km^2. In areas of sympatry, the long-tailed weasel is less abundant than is the ermine. Direct data are lacking on population trends, but fur return data from the Hudson's Bay Company in Canada suggest that *M. f. longicauda* populations have shown a progressive decline. The decline is believed to be partially due to a loss of habitat. Locally, populations of long-tailed weasels are fairly stable, showing less population fluctuation than either the ermine or the least weasel. More recently, Sheffield and Thomas (1997) stated that *M. frenata* in Alberta had a ten-year cycle synchronous with that of the snowshoe hare.

2.3.4 Activity Patterns

While long-tailed weasels can be active day and night, they are primarily nocturnal. Radio-tracking data on long-tailed weasels revealed that excursions from the den generally began one hour after sundown and lasted for one to three hours, after which the weasel returned to its original, or another den. Males are extremely active during the breeding season; however while rearing young, females often travel farther than males, to search for food and den sites. Excursions are limited during winter probably because of vulnerability to heat loss (Fagerstone 1987). Three types of vocalizations have been characterized: a trill, a screech, and a squeal (Svendsen 1976). Vocalizations and visual signs may have some significance in territorial defense (Fagerstone 1987).

2.4 Ermine or Short-tailed Weasel *(Mustela erminea)* M-MUER

2.4.1 Ecology and habitat requirements

The ermine, or short-tailed weasel is intermediate in size between the long-tailed weasel and the least weasel. In summer, its pelage is reddish-brown above and creamy white below, changing entirely to white in winter, with the exception of the black tail-tip. Body weights of adult ermine in North America range from 56 to 206 g, with smaller animals in the south. Like other weasels, the ermine exhibits sexual dimorphism, with males being 40 - 80% heavier than females. The skull of the male may be 9 - 24% larger than that of the female (King 1983).

The ermine inhabits a variety of habitats. In North America, it is most abundant in boreal, montane, and Pacific Coast coniferous forests (Fagerstone 1987). Ermines avoid dense forests and settle in successional or forest-edge habitats, wet meadows, marshes, ditches, riparian woodlands, or river banks with high densities of small mammals (Simms 1979*a*; Simms 1979*b*; King 1983, Fagerstone 1987). Simms (1979*a*) found that ermine exhibited a decided preference for early successional communities and avoided forested habitats. Simms (1979a) also found that male ermine were more often associated with shrubs than were females. Males generally occupy a wider range of habitats than females and both male and female ermines occupy more habitat types during spring and summer than during fall and winter (Fagerstone 1987).

Ermine diets appear to be influenced by prey availability, and hence, habitat. Simms (1978) found the remains of collared and brown lemmings in ermine scat from the central Arctic. Simms (1979a) discusses the ability of female ermines to exploit the subnivean environment due to their optimum size (small cranium), whereas males, are often too large. Simms (1979a) also suggested that ermine are vole specialists, which is consistent with other literature (*e.g.*, Erlinge 1977, Fitzgerald 1977). Fagerstone (1987) mentions rats, chipmunks, pikas, nesting birds, amphibians, reptiles, earthworms, and insects as prey. King (1983) cites an account of ermine snatching fish from a stream. Variable dietary composition is likely, changing with prey availability (Fagerstone 1987).

Ermine are well adapted to snowy environments and they range into alpine areas (King 1983). Fitzgerald (1977) found ermine living year-round at elevations of 2000 - 3000 m in the Sierra Nevadas. The long, thin shape of ermine increases its thermoregulatory demands in cold climates, and snow provides vital insulation against extremes in air temperature (Chappell 1980).

Size differences may affect the reproductive success of both males and females. Males are polygynous, and larger males are presumed to have an advantage in obtaining mates because they will be more capable of over powering a rival male who is smaller (King 1983). Because females raise their young alone, smaller females may be more efficient when hunting small prey, therefore their energy requirements for hunting would be lower than that of larger female, providing that the abundance of small prey is sufficient to sustain the smaller female. In addition, smaller females have smaller absolute (but not relative) energy requirements because they are not required to expand their territory to search for larger prey items. This suggests selection for larger males and smaller females in ideal situations (when smaller males do not obtain mates and small prey sustains smaller weasels). As with other ecological traits, these assumptions may not always hold true.

Reproduction is discussed by King (1983). Ovulation is believed to be induced by copulation. Delayed implantation results in a mean gestation off 283 days, with a maximum recorded of 378 days (from captive-bred ermine). Active gestation from implantation to parturition takes four weeks. A single litter is produced in the spring, most often in April. The number of offspring per litter ranges from four to thirteen, but four to eight is the usual number, with equal sex ratio. Reproductive success is strongly influenced by food supplies prior to parturition.

2.4.2 Distribution and status

Species Range

The ermine has a circumboreal range throughout the Holarctic and has been introduced into New Zealand (King 1983).

Provincial Range

Ermine occur throughout British Columbia, including Vancouver Island and the Queen Charlottes (Cowan and Guiguet 1965). Local distribution of ermine is broadly related to that of small rodents and lagomorphs (King 1983). Because ermine are well adapted to living in snowy conditions, snow presents little obstacle to the distribution (King 1983).

Status

Mustela erminea haidarum is globally ranked as 'G5T2'. This indicates that *M. e. haidarum* is an imperiled subspecies of an otherwise common species. Provincially red listed, its ranking is 'S2', indicating that this subspecies is *Imperiled*.

Mustela erminea anguinae globally ranked as 'G5T3', indicating that *M. e. anguinae* is an imperiled subspecies of an otherwise common species. Provincially blue listed, its ranking is 'S3', which indicates that this subspecies is *Vulnerable*.

The other three subspecies, *M. e. fallenda*, *M. e. invicta*, and *M. e. richardsonii* are found on the provincial “Yellow List”.

2.4.3 Density Patterns

Home ranges of males are larger than females by factors of two to six, and may overlap those of several females (Fagerstone 1987). Females exclude other females from their home ranges, and tend to avoid any male on whose range they live (King 1983). Where prey is abundant, home ranges tend to be small. Estimates of home range size for individual males vary from 0.04 – 2.0 km^2, with most averaging 0.10 – 0.40 km^2 (King 1983). In southern Ontario, male home ranges averaged 0.20 – 0.25 km^2, and female home ranges averaged 0.10 – 0.15 km^2 (Simms 1979b). In North America, home range size varies with latitude; ermines in the south tend to have smaller home ranges than those in the north (Fagerstone 1987). Ranges are marked by scent from the anal glands. By continually visiting all parts of its home range a resident male may patrol the boundaries and maintain fresh scent marks in the course of foraging (King 1983).

The density and structure of ermine populations are unstable, because life spans are short and reproductive capacity is high (King 1983). Populations are greatly influenced by fluctuations in the supply of prey, especially of small mammals. Estimates of population densities have ranged from one ermine / 0.17 km^2 (Simms 1979b) to one / 0.50 km^2 (King 1983). Large-scale movements during breeding season are not uncommon, as juvenile males attempt to establish breeding territories (King 1983).

2.4.4 Activity Patterns

Although ermine may be active day or night, they are primarily nocturnal (Fagerstone 1987). They typically move rapidly, investigating every hole and crevice, stopping often to survey their surroundings. Ermine are active for short periods, alternating between activity and rest periods every three to five hours (King 1983, Fagerstone 1987). Three types of vocalizations are described: a screech, an aggressive squeal, and a trill. Vocalizations and visual signs may have some significance in territorial defense (Fagerstone 1987).

2.5 Least Weasel *(Mustela nivalis)* M-MUNI

2.5.1 Ecology and habitat requirements

The least weasel is the smallest mustelid and smallest member of the order Carnivora in North America. In summer, its pelage is brown above and light below changing to entirely white in winter. Male least weasels weigh 60 - 90 g and females weigh 35 - 70 g. In addition to its smaller size, the least weasel can be distinguished from the long-tailed weasels and ermine by having a tail that is less than one fourth the length of the head and body and without the distinctive black tip (Fagerstone 1987).

The least weasel inhabits a variety of habitats. In the north, it can be found on the tundra and in coniferous forest and woodland. Further south, the least weasel tends to occupy open areas. Commonly found in meadows, grasslands, and river bottoms, the least weasel appears to be less selective of habitat than either long-tailed weasels or ermine (Fagerstone 1987). The local distribution of least weasels is probably a function of small mammal abundance.

The least weasel specializes in very small prey, primarily mice. In North America, voles, deer mice, and harvest mice make up most of the diet (Fagerstone 1987). Other food sources include shrews, moles, lemmings, insects, ground-nesting birds, and rats (Erlinge 1975, Fagerstone 1987). Least weasels are small enough to pursue rodents into runways, burrows, and nest chambers, and therefore spend more time hunting in these areas than do long-tailed weasels or ermine (Fagerstone 1987). Cushing (1984) showed that least weasels are able to detect mice in estrus, and suggested that a preference for these mice may be an advantage because prey density near a female that has a litter or that is attracting mates will be greater.

The least weasel may breed year-round, with males and females becoming sexually mature at three to four months of age. The age at reproduction, number of litters, and rate of development of the young all appear to be strongly influenced by prey abundance. If food is abundant, a female can reproduce two to three times a year (Heidt *et al.* 1968). Testes of most males are active between March and August, but they may be active at other times of the year if food is abundant (Fagerstone 1987). Unlike long-tailed weasels and ermine, delayed implantation does not occur in least weasels, and gestation is about 35 days (Heidt *et al*, 1968, Fagerstone 1987). The number of young ranges from one to ten, but averages four to five (Fagerstone 1987).

The differences in reproductive strategies among the long-tailed, short-tailed and least weasels could be the result of rapid population turnover within least weasel populations. Sandell (1984) theorized that differences in breeding strategy exist because of rapid population turnover and the least weasels' dependence on fluctuating prey populations. The rapid population turnover would favour selection for a higher reproductive output, as well as create strong selective pressure against delayed implantation (Sandell 1984, Fagerstone 1987).

2.5.2 Distribution and status

Species Range

The least weasel has a holarctic range extending across Eurasia, Alaska, Canada, and the northern United States (Nagorsen 1990). In North America, the least weasel occurs from the Arctic south to central British Columbia and Montana, and east to the Atlantic coast of Canada and the United States. In the eastern United States, the range extends south to roughly 40° north latitude (Fagerstone 1987).

Provincial Range

The least weasel is sparsely distributed in the northern and central sections of the province, with specimens taken from Vanderhoof, the Peace River district, and Ootsa Lake (Cowan and Guiguet 1965, Nagorsen 1990).

Status

Although widespread, the least weasel is considered rare throughout its entire range (Fagerstone 1987). The least weasel is currently on British Columbia's "Yellow List", which lists any indigenous species or subspecies which are not at risk.

2.5.3 Density Patterns

Estimates of the size of a least weasel's home range vary widely, possibly because the area required by an individual depends on prey densities. In North America, least weasel home range size is poorly documented. Polderboer (1942) reported that when voles and mice are abundant, home ranges are small, about 0.02 km^2. In eastern Poland, Jedrzejewski *et al.* (1995) found home ranges of males to be 0.11 – 0.37 km^2 during periods of high prey abundance and 1.17 – 2.16 km^2 during "crash" years. It should be noted that European least weasels are approximately the size of North American ermine, and therefore their home ranges would be expected to be bigger. Published estimates of home range size extend from 0.01 to 0.15 km^2. Throughout its northern distribution, it may be difficult to accurately estimate home range size because the least weasel spends much of its time under the snow (Fagerstone 1987). Female least weasels have separate, smaller territories than those of males. Males travel outside of their territory during breeding season, which increases their probability of encountering a sedentary female (Erlinge 1977, Fagerstone 1987).

Density studies of least weasels are difficult due to a high mortality rate and a mean life span of less than one year (Fagerstone 1987). In eastern Poland, Jedrzejewski *et al.* (1995) found densities of least weasels to fluctuate wildly with prey populations of voles and mice. In years with a moderate density of rodents, there were 41.9 – 47.6 individuals/10km^2, during a rodent outbreak, densities increased to 101.7 individuals/10km^2, while during a rodent population crash, densities decreased to 19.1 individuals/10km^2. Increase of weasel numbers from spring to midsummer was positively related to the spring number of rodents. Although autumn and winter declines were apparently not related to rodent density changes. These findings exemplify the sensitivity of least weasel populations to changes in abundance of prey species. Densities of North American least weasels may be higher than those of European least weasels because of their smaller size (Fagerstone 1987).

2.5.4 Activity Patterns

Because of their small size and high metabolic rate, least weasels spend much of their time hunting. However, they are unable to consume more than a few grams at a time, or more than one meal every few hours, and, as a possible result, they often cache food in their dens (Gillingham 1984, Fagerstone 1987). Long movements may be limited by the necessity to return to a den. This may explain the tendency of least weasels to remain in relatively small areas of their home range for several days at a time (Fagerstone 1987). It is assumed that like long-tailed weasels and ermine, least weasels are active both day and night, but primarily at night.

3. PROTOCOLS

3.1 Sampling Standards

3.1.1 Habitat Data Standards

A minimum amount of habitat data must be collected for each survey type. The type and amount of data collected will depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory. As most, provincially-funded wildlife inventory projects deal with terrestrially-based wildlife, standard habitat attributes from the terrestrial Ecosystem Field Form developed jointly by MOF and MELP will be used. However, under certain circumstances, this may be inappropriate and other RIC-approved standards for ecosystem description may be used. For a generic but useful description of approaches to habitat data collection in association with wildlife inventory, consult the introductory manual, *Species Inventory Fundamentals* (*No.1).*

Raphael (1994) includes inventory of land with suitable attributes as a theoretical means of assessing marten populations. This assumes that there is an adequate understanding of habitat requirements, that these attributes have been mapped, and that suitable habitats are stocked. For example, the habitat suitability index (HSI) for marten depends on five attributes: percent canopy closure, average diameter of canopy trees, number of canopy layers, percent deciduous species in the overstory, and percent of ground surface covered by woody debris greater than 7.6 cm in diameter (Allen 1982). Data on the last attribute are not routinely collected.

The habitat requirements of martens are not yet well understood, and thus the HSI is not yet very definitive (Raphael, pers. comm.). For example, Raphael (pers. comm.) has found substantial numbers of marten in a recently burned area, which the present HSI would have classed as unsuitable. Thus, with current understanding, HSI analysis might not include areas that are, in fact, suitable for martens. Despite the limitations, habitat inventory might be useful in assessing potential distribution and the size and geometry of habitat in certain regions. A photo-trapline survey on northern Vancouver Island showed that martens were apparently common in second-growth forests where conventional wisdom about the need for mature old-growth forests would have predicted that few would occur.

Lofroth and Banci (1991) describe a plan for developing a marten habitat suitability index model for British Columbia. Habitat suitability indices have not been developed for weasels.

3.1.2 Health and Safety Standards

There are safety concerns related to travel in remote areas, particularly by individuals. The potential danger is especially great if travel is by snow machine, skis, or snowshoes, and there is concern about winter storms. In some areas at some times of year, bears or cougars may pose a potential threat.

Winter and Remote Area Operations

Field operations, especially those conducted in winter and in remote areas are attended by certain risks. Field personnel should receive adequate training in wilderness survival and first aid, and field parties should carry emergency survival equipment. Safe operating procedures should be established, including a clear record of where parties are working and traveling and when they are expected to return.

Bait Handling

Raw chicken and other perishable materials which are used as baits can spoil, resulting in a health hazard. Disposable rubber gloves should be used when handling raw meats. Workers should carry soap (or disposable wipes) so that they can wash their hands after handling baits.

Bears and Cougars

If there is a need to conduct surveys where bears and/or cougars are present, workers should take appropriate precautions against dangerous encounters with these large carnivores. If the situations is such that workers will need to carry firearms, it will be necessary to acquire the appropriate Firearms Acquisition Certificate (FAC) and training. The use of baits attractive to carnivores may increase the potential danger.

Sooting Track-Plates

Workers should avoid breathing soot and fumes from the acetylene or kerosene torches while applying soot to track plates. This will require working in a well-ventilated area. Workers must also ensure that acetylene tanks are securely chained, and that other flammable materials are well away from the work area.

3.1.3 Survey Design Hierarchy

Marten and weasel 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 marten and weasel detection station survey. A survey set up following this design will lend itself well to standard methods and RIC data forms.

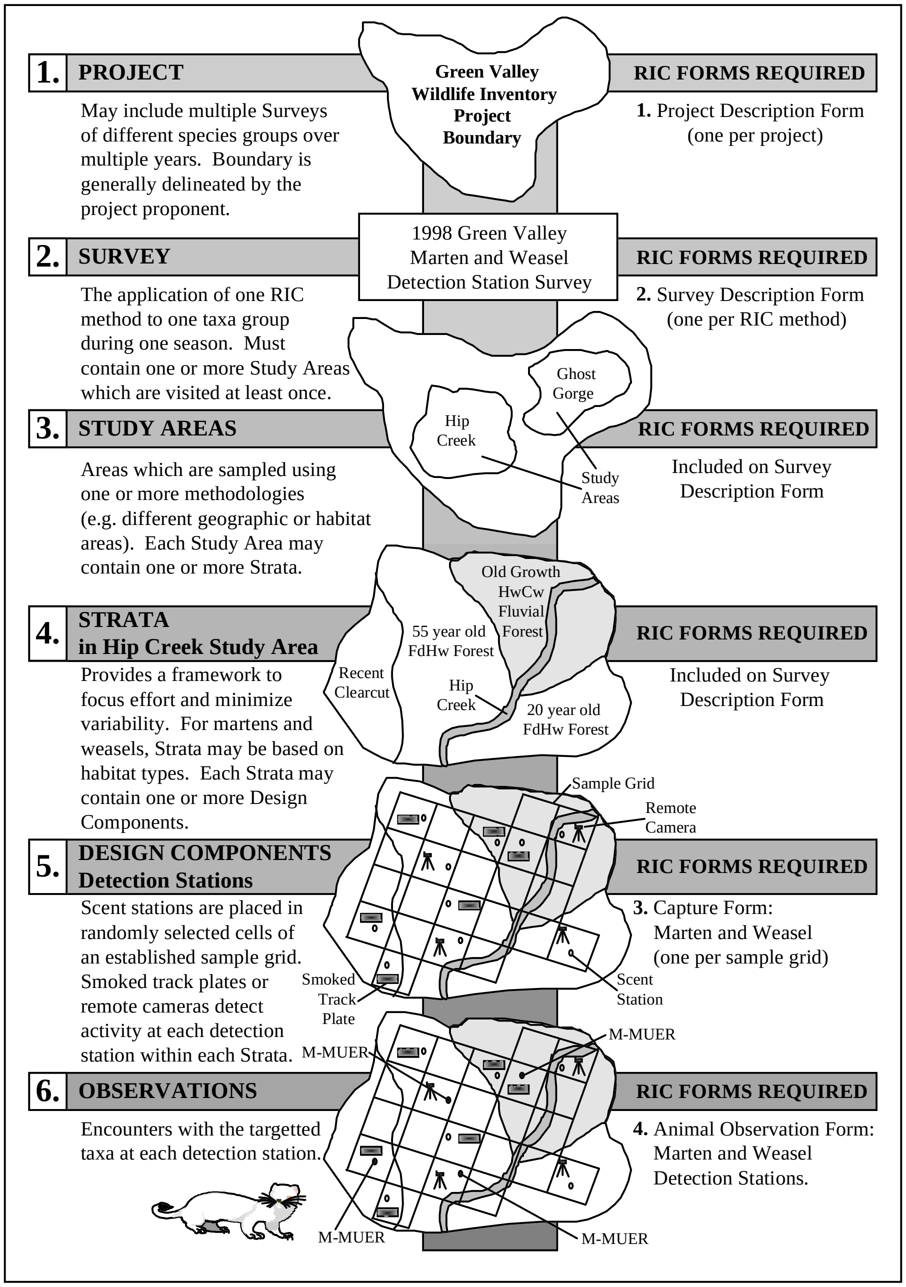

Figure 1. RIC species inventory survey design hierarchy with examples.

3.2 Biological Factors Affecting Inventory

Biological factors inherent to martens and weasels affect the approaches that may be usefully taken to routinely inventory and monitor populations. Chief among these are behaviour and trapability and the large changes in population density that occur among years and seasons.

Martens and weasels, along with other mustelids, exhibit behaviours that result in sex-biased catches and in both positive and negative responses to traps (*i.e.*, they become “trap-happy” or “trap-shy”). Both attributes lead to serious problems in conducting statistically valid trapping surveys or mark-recapture studies.

3.2.1 Sex-bias

Sex ratios that depart significantly from 1:1 are usually observed in trapped samples of mustelids from fur harvest or research (Buskirk and Lindstedt 1989). Usually the bias is in favour of males. Yet it is males that typically occur in lower density (Tables 2, 3, and 4). A number of factors may account for this paradox.

Trapper selectivity

Bias in fur returns may result when the pelt of one sex is more valuable than that of the other. This effect may be amplified when regulations limit the number of pelts that a trapper may legally possess (Powell 1985).

Sex ratio within the population

The departure from a 1:1 sex ratio might reflect a larger number of one sex within the population. While this possibility cannot always be excluded, Simms (1979a) reported equal numbers of live-trapped male and female *M. erminea* and *M. frenata* in his southern Ontario study area, although he caught males more often.

Size-dependent factors

Buskirk and Lindstedt (1989) point out that a number of factors, such as time to cross a home range, can vary according to body size and home range size. Male martens and weasels are larger than females.

Sexual dimorphism and home range size

Because male mustelids have larger home ranges that do females (King 1990, Katnik *et al.* 1994), their home ranges are more likely to include traps (or more traps) than those of females. This problem can be reduced by setting traps or other detection devices in a line (Buskirk and Lindstedt 1989).

Trap spacing

King (1975) found large differences in rates of capture of male and female *M. nivalis*. She concluded that this was in large degree a function of trap spacing. She pointed out that when the inter-trap distances were larger than the diameters of the smallest (*i.e.*, female) home ranges, home ranges of some females would contain no traps.

Sexual differences in sensory acuity

Without citing supporting data, Buskirk and Lindstedt (1989) speculated that there may be inter-sexual differences in sensory abilities (*e.g.*, olfaction) that might lead to differential trappability.

Sexual differences in behaviour

Buskirk and Lindstedt (1989) suggest that male mustelids may engage in more territorial maintenance behaviour than do females. This could result in males patrolling their territories more often or more thoroughly than might females. Males might also react to traps differently from females. In any event, King (1990) reports that female weasels are more difficult to catch than are males.

Sexual differences in response to snow

Lofroth (pers.comm.) reports that male martens, which are larger and heavier than females, apparently have more difficulty in moving through fresh, deep snow than do females. Thus, males may be less active after a snowfall until the snowpack has settled and become denser.

3.2.2 Trap response

Some weasels learn to avoid traps (King 1990). Martens may become "trap happy" or "trap shy," depending on the individual (Lofroth, pers.comm.).

The "population" of weasels inhabiting an area is composed of a complex of resident and transient individuals (Powell, pers. comm.). The status of these individuals may change as food resources change, with some transients settling down to become residents during periods of food abundance, and some residents becoming transients during periods of food scarcity. Such changes occur between years and between seasons. King (1990) states that resident weasels, confident of winning encounters with other weasels, tend to be bolder than transients, and consequently, residents may be more easily trapped.

Seasonal and annual changes in trapability may also result when food scarcity causes animals to search harder and perhaps be less cautious about approaching baits.

3.2.3 Responses to baits

Martens and weasels readily come to baits, and a variety of materials have been used including strawberry and raspberry jams, commercial marten lures, fish (fresh and canned), canned tuna cat food, and fresh chicken parts (especially wings, which are inexpensive and lend themselves to being tied to traps, camera trigger systems, etc.). Rotting is not a problem since mustelids commonly feed on carrion.

The attractiveness of baits probably varies according to several factors. Weather and temperature affect the rate of decomposition and the dispersal of odours. The availability of natural food may affect the level of searching activity and degree of motivation of martens and weasels to discover and investigate baits. The consensus is that martens (and presumably weasels) are most difficult to attract in summer because of the greater availability of prey and other natural foods (Bull *et al.* 1992, Raphael, pers. comm.).

Fowler and Golightly (1994) conducted field tests on the effectiveness of fresh chicken and canned tuna cat food in attracting martens to track-plate and camera stations in spring, early summer, and late summer. They found no significant difference in the effectiveness of the baits according to season, but chicken was more effective than tuna cat food ($p<0.02$).

There are practical considerations with respect to using baits in field programs in British Columbia. Fresh chicken can be messy, and maintaining supplies may be difficult in remote areas. There are also health concerns for workers who have to handle potentially spoiled meat. Most of these concerns are reduced with tuna cat food. With either bait, it is important to remove old baits and cans from the survey area to avoid spreading competing baits, and to maintain good housekeeping. The potential for attracting bears to baits is another reason for conducting surveys in late winter - early spring, when bears are in hibernation.

3.2.4 Changes in population density

Population size of martens and weasels may change by an order of magnitude among seasons and years. These changes are driven largely by changes in food supply, although the relationships may be complex in systems with several herbivorous prey species and several predator species. King (1990) presents an excellent review on population dynamics of weasels.

Home range size and density vary considerably (Tables 2, 3, and 4). Much of the variability can be explained by differences in prey density, which in turn, varies according to habitat and position in the population cycle.

Least weasels are usually rare, yet their populations sometimes irrupt. Mr. P. Fryklund, a Minnesota fur buyer interested in natural history, recorded the number and species of weasels that he handled each year (Swanson and Fryklund 1935). In 32 years from 1895 to 1927, he received only seven least weasels. In the following three years, from 1927-1929, he received three least weasels. However, in the next two winters, trappers presented him with 59 and 84 least weasels each, and yet he received only three in the next five winters. Despite possible biases associated with trapping, clearly there had been a population irruption in the late 1920s. There was a similar irruption in North Dakota in 1969-79 (King 1990). During periods of high density, least weasels may actually expand their range. They were unknown in Kansas until 1965, but in the subsequent 15 years, they spread some 500 km south into Oklahoma (Choate *et al*. 1979). Cowan and Guiguet (1965) state that least weasels are sparsely distributed in the central and northern parts of the province and are not abundant anywhere in B.C.

Martens also show a sexual dimorphism and considerable variability in home range size (Table 2). The studies from all over North America cited by Powell (1994) showed variation in male home range sizes from 3.4 to 11 km^2 and in female home range sizes from 1 to 13 km^2. In general, within each study area, male home ranges were larger than those of females by factors of 2-3. Lofroth (1993), working near Smithers, British Columbia found marten home ranges with a mean size of 5.2 km^2 for males (range: 4.05 - 6.27 km^2), and a mean of 3.2 km^2 for females (range: 1.25 - 4.41 km^2).

3.3 Inventory Surveys

The table below outlines the type of surveys that are used for inventorying martens and weasels for the various survey intensities. These survey methods have been recommended by wildlife biologists and approved by the Resources Inventory Committee.

Table 5. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Type of Survey	Forms Needed	Intensity*
Detection Devices	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture Form - Marten & Weasel Stations • Animal Observations Form- Marten & Weasel Detection Stations • Ecosystem Field Form	• PN
Snow Tracking	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form- General • Animal Observations Form- Marten Snow Tracking	• PN
Mark-Recapture/Resight	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture Form - Marten & Weasel Station • Animal Observation Form - Marten & Weasel Capture/Recapture (Resight)	• AA
Any Survey Type	• Wildlife Inventory Survey Collection Label - is used whenever a voucher specimen is collected.	

*PA = Presence / Absence (*i.e.*, detection surveys); RA = relative Abundance; AA = Absolute Abundance

3.4 Presence/Not Detected

The predilection of mustelids for investigating baits suggests that techniques using baits are valuable for surveys to determine the presence of marten and weasels. For routine surveys conducted by biologists or technicians, track-plate stations supplemented by automatic camera stations are recommended. In combination, the camera stations may confirm the presence of certain species whose tracks may be confused (*e.g.*, marten and fisher).

In preparing this protocol, Zielinski and Kucera (1995) has been drawn on extensively. The essential information has been included, but it is recommended that potential users consult Zielinski and Kucera (1995).

Recommended Methods:
(a) A combination of cameras and track-plate stations used as detection devices set-up at stations.
(b) Snow-tracking when conditions are favourable.
Note: Snow tracking alone is generally not an effective method for differentiating between different species of mustelids unless employed by a very experienced observer in appropriate snow conditions. The potential for confusing different species is great. However, the consequences of confusing marten tracks with fisher tracks are less severe if the target species is marten. Because fishers occur in such low densities, mistaking a fisher track for a marten track is not likely to occur very often. However, if snow-tracking yields a record of a possible fisher, confirmation should be sought using the recommended combination of cameras and track-plate station.

3.4.1 Detection Devices

Sooted track plates

Tracks and other sign left by animals have long provided important information to biologists. Tracks left in snow or soil provide some information, but sometimes there is ambiguity about identity. The lack of suitable substrates for tracks is also a common problem, except where snow occurs at the right times and in the right consistency. To overcome these problems, various workers have developed devices, often incorporating baits, with artificial substrates that can record the tracks (*e.g.*, Mayer 1957, King and Edgar 1977). The sooted track-plate enclosed in a wooden (or metal and plastic) cubby is the best all-round design. Fowler and Golightly (1994) recorded many species using this type of track-plate, including Marten, Ermine, and Long-tailed Weasel.

Track-plate stations consist of a sooted (smoked) aluminum plate and a piece of contact paper placed, sticky side up, housed in a wooden cubby (Figure 2). Animals are attracted into the cubby by the bait placed inside or possibly from the presence of what may appear to be a shelter or burrow. Individuals that enter the cubby get soot on their feet which is transferred to the contact paper. Useful track images may also be present on the sooted plates themselves. The tracks can be ‘lifted’ from the track plate using wide, transparent tape to transfer the image to a sheet of white paper. Unlike tracks left in snow or soil, these impressions provide a permanent record and permit consultations with experts on difficult identifications. Because track-plate stations do not require particular weather conditions, they can be used during much of the year.

In addition to providing permanent and consistent track impressions, track-plate stations are inexpensive and easily transported, and they involve no potential injury to focal animals. Because a permanent record of tracks can be kept, it is possible to study difficult-to-identify tracks at one's leisure and to send photo-copies (even by fax) to authorities for verification. The permanent record also permits detailed measurements and the application of discriminant analyses in making identifications.

Disadvantages of track plate stations include the difficulty of accurately distinguishing among tracks of related species of similar size (*e.g.*, *Mustela erminea* and *M. nivalis*). Standard identification references (*e.g.*, Murie 1954), which are based on tracks left in snow or fine soil substrates, are virtually useless. The records that are left on sooted (smoked) aluminum and contact paper are more detailed than those left on natural substrates. Keys have been developed for the identification of tracks left at counting stations (Taylor and Raphael 1988, Zielinski and Truex 1995), (see Appendix B). Because existing track-plate keys do not include all species that may be encountered in British Columbia, it may be necessary to do further work with captive animals to help ensure reliability.

Remotely-triggered cameras

To help confirm the identity of species present in the Study Area, the track-plate stations can be supplemented with remotely-triggered cameras (Figure 3A and 3B). Fowler and Golightly (1994), using an array of track-plates supplemented by cameras, detected a total of 21 species in their northern California study area. Track-plates recorded 17 species, including marten and short-tailed and long-tailed weasels. The cameras recorded 12 species, which included marten, but neither species of weasel. A detailed description of methods and problems associated with camera stations can be found in Kucera *et al.* (1995), a copy of which is available in the MOELP Library in Victoria. For plans to make six metal and plastic cubby’s, which are light and more compact than the wooden version, see Foresman and Maples (1997), a copy of which is also available in the MOELP library in Victoria, British Columbia.

There are two basic types of camera set-ups that are suitable for remote detection stations: active infra-red and dual-sensor (passive infra-red and microwave motion sensors) coupled to good-quality 35 mm cameras (~CDN$750). A third type, not recommended, uses cheap 110 cameras (~CDN$20) that are mechanically actuated and unreliable. Baits are used to draw animals into the area where they will trigger the camera systems and are photographed. Although the 35mm/active infra-red systems are much more expensive, they are much more reliable, require much less labour to set up and maintain, and are ultimately more cost-effective (See Table 7).

Table 6. Summary of remotely triggered camera system attributes (Data from Kucera *et al.* 1995.)

Type	Weight	Labour	Auto-Wind	Data Back	Reliability	Cost
Active IR	2 kg	low	yes	yes	high	$750
Dual-sensor	14 kg	low	yes	yes	high	$625
110 instamatic	1 kg	high	no	no	low	$20

There is a need to standardize camera set-ups to maintain constant effort between stations. Because most mustelid detection occurs at night, standardization must be based on the area illuminated by the flash unit (K. Foresman, pers. comm.). Additionally, if attempting to detect individuals that had been previously captured and marked, the field of view must include a clear view of the marking mechanism (permitting animal cooperation).

Active infra-red systems require that an animal break a beam of infra-red light to trigger the camera. The Trailmaster 1500™ (Goodson and Associates, Inc., 10614 Widmer, Lenexa, KS 66215; ph: 1-800-544-5415) includes an IR transmitter, receiver, and 35 mm camera with internal flash, auto-winder, and a data-back which records date and time of events (CDN$750). With the TM Intervalometer accessory (CDN$350), the length of time that the beam must be broken is adjustable (0.05-1.5 second), as is the length of time between triggering (0.2-98 minutes). There are other accessories for data collection and analysis.

The IR transmitter and sensor are each powered by four C-cell batteries, which last for about 30 days in ideal situations (mild and dry climates). The Yashica AW Mini camera, which is employed in the 1994 Trailmaster systems, uses two AA batteries which last about two weeks.

The Trailmaster is weatherproof, allowing it to operate in rain and snow. Kucera *et al.* (1995) tested it in a freezer at -17°C for two weeks, and at -7°C for two more weeks. Additional protection may be necessary to shield the lens from rain and snow.

Dual-sensor systems consist of an automatic camera triggered by both microwave motion and passive IR detectors. Both systems have to be triggered to release the camera's shutter. If one system malfunctions, the other will override it. The dual-sensor systems require a 12-v "golfcart" battery. The system used by Kucera *et al*. (1995) was housed in a weatherproof aluminum box, which also offered protection from damage by bears and other animals. The cost was about CDN$625. Similar units are manufactured in British Columbia by Cygnus and cost approximately CDN$750.

Office procedures

- Review the introductory manual No. 1 *Species Inventory Fundamentals.*
- Obtain maps and outline the Project Area (*e.g.*, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the Project Area from maps.
- Delineate one to many Study Areas within this Project Area. Study Areas should be representative of the Project Area if conclusions are to be made about the Project Area. For example, this means if a system of stratification is used in the Sampling Design then strata within the Study Areas should represent relevant strata in the larger Project Area.

Sampling design

- Presumably, sampling is intended to relate the presence of martens and weasels to particular habitat types, so it is necessary to ensure that Study Areas adequately represent the habitats of interest.
- Study Areas should be 4.0 km square (Zielinski and Kucera 1995).
- Each Study Area should contain 6-12 track-plate stations and two remote camera stations. The stations should be placed at least 1000 m apart; the camera stations should be placed at least 2.0 km apart.
- If terrain and/or vegetation in the area does not permit a square/rectangular sample area, select an area along a stream, trail, or road of 5 km or longer and place detection devices at 1000 m intervals.
- This level of intensity will permit four or five areas to be surveyed simultaneously by a crew of two.

Survey timing

- Detection survey programs should be conducted in the late winter to early spring period. During this time, populations of prey are typically minimal, therefore mustelids tend to be more active in their search for prey and, presumably, baits will be more attractive to them. There may be significant logistic and safety problems associated with winter work (see Health and Safety Standards). An effort should be made to avoid periods when bears are active or when snowfall might bury equipment.
- With regards to other seasons, martens, and presumably weasels, are difficult to attract in summer. Surveys conducted in fall may encounter large numbers of young that are dispersing through, or occupying marginal of unsuitable habitats, and will not survive the winter. If the aim is to identify important habitats that are regularly occupied, fall surveys should be avoided.

Sampling Effort

- Surveys should be conducted until the target species have been detected or for a minimum of 12 nights.
- The track-plates should be checked every other day and the baits renewed as necessary.

- Start on the day following the second night after the devices have been deployed.
- When the number of stations was between six and twelve, Zielinski *et al*. (in prep.) found that the mean day of first detection of marten was day 3.7, not including those sessions during which no detections occurred. No such data exist for weasels.

Personnel

This program is designed so that a field crew of two should be able to sample four or five areas simultaneously, depending on the difficulty of the terrain and ease of travel between areas. Two persons are required to deploy and remove the devices in each Study Area. Once established, Study Areas can be visited and the equipment serviced every other day by only one person, unless safety considerations dictate that two people work together.

- Surveyors competent in identifying tracks (minimum crew of two).
- Because a degree of skill is involved in identifying tracks, it will be necessary to have some sort of training program. Approximately two weeks of on-the-job training with someone seasoned in identifying tracks will be necessary for new technicians (Raphael, pers comm.).
- Ensure that at least one member of each field crew is thoroughly familiar with the operation of the camera and infra-red triggering systems.

Equipment

A list of useful field equipment for conducting a track-plate and camera detection survey is provided. (Based on Zielinski 1995.) Details of track-plate construction follow.

Orientation Equipment:

- maps
- air photos
- GPS units (use NAD83)
- flagging
- compass
- pencils
- indelible markers
- duct tape

General:

- tool / tackle box
- hatchet
- small folding shovel
- scissors
- pliers
- garbage bags
- backpack
- food
- emergency equipment
- bear safety equipment
- ammunition

Track Plate Equipment:

- aluminum track plates
- acetylene / torch
- surgical gloves
- rags / steel wool to clean plates
- Con-tact™paper
- plywood for cubbies
- rope, tubing, inner tube
- plate carrying case
- canned tuna cat-food
- can opener
- raw chicken
- 3-ring binder, one/area
- data forms
- document protectors
- indelible marker
- transparent tape (wide)
- track ID references

Camera Equipment:

- Remote camera set-ups. An active infra-red camera system, such as the Trailmaster 1500™ (Goodson & Associates, Inc., 10614 Widmer, Lenexa, KS 66215, USA; ph: 913-345-8555, fax: 913-345-8272), is recommended. These systems consist of an infra-red transmitter, receiver, and automatic 35 mm camera. The batteries used in the 1994 Trailmaster 1500™ with the Yashica AW Mini™ will last for about two weeks.
- Film (100 and 200 ASA- 36 exposure) the flash used in the Yashica AW Mini™ camera is sufficient to illuminate a subject at 6 m using ASA 100 film; the distance increases to 12 m with ASA 200 film.
- Batteries

Check with a recent practitioner for up-to-date advice on materials.

Preliminary field procedures

Track plate and cubby construction (Figure 2).

Zielinski (1995) describes three devices for recording the tracks of animals. Two of the devices are covered, sooted aluminum plates with a piece of contact paper (paper with a tacky adhesive on one side) placed sticky side up. When animals walk on the sooted surface, their feet pick up soot that is deposited on the contact paper, leaving a clear black image on a white background.

The alternative is an unenclosed sooted track-plate. This device does not use contact paper to record the tracks; instead the image is created when the animal walking on the plate removes soot. This device is completely open to the weather.

It is suggested that the sooted track-plate enclosed in a wooden cubby is the best all-round design. Fowler and Golightly (1994) recorded many species using this type of track-plate, including martens, ermine, and long-tailed weasels.

The sooted aluminum plates can be protected by stiff plastic sheets formed into a half-cylinder dome or by "cubbies" made from the most economical grade of exterior plywood. The wooden cubbies, although heavier than the plastic domes, better protect the track-plates and are sturdier, allowing limbs and other debris to be placed on them for camouflage. Images can also be obtained from the sooted plates using clear tape, which is then transferred to a sheet of plain white paper.

<u>Plywood cubbies</u>

- Construct the plywood cubbies to house the track plate of 1.3 cm (0.5 in) standard- or cull-grade exterior plywood, with interior dimensions of 20x20x80 cm (8x8x32 in).
- Cut grooves 1.6 cm (0.63 in) wide and 0.8 cm (0.32 in) deep in the tops and bottoms (25x80 cm; 10x32 inches). The edge of the side pieces (20x80 cm) (8x32 in) will easily fit into the grooves.
- The cubbies can be held together with rope, “rubber bands" cut from tire inner tubes, or other devices. 3.75 units can be constructed from one sheet of plywood (120x240 cm; 4x8 ft).

<u>Track Plates (Figure 2)</u>

- Construct track plates of 0.063 gauge aluminum sheeting, 20x75 cm (8x30 in).
- The plates should be sooted in a well-ventilated area using an acetylene torch with its oxygen valve blocked with tape. Alternatively, a smoky kerosene torch can be used.
- To transport the plates, it is necessary to construct a carrying box from 13 mm (0.5 in) plywood. The box should be constructed with a number of slots that can accommodate the sooted plates so that they are not touching.
- Contact paper (Rubbermaid Inc.,) cut to 11.5x30 cm (4.6x12 in) should be attached to the centre third of the track plate, with the sticky side up. Do not remove the protective covering until the plate is to be put in place in the field. Use duct tape to hold the contact paper on the sooted plate.

Field Procedures

Marking and Locating Track-Plate Stations

- Mark the site of each track-plate station with conspicuous plastic flagging (collect and properly dispose of the flagging at the end of the survey).
- Mark sites on the largest scale map available.
- Detailed notes/sketches should be entered on the data form.
- In remote areas, it may be desirable to use a satellite positioning device (referenced to NAD83).

Remote camera set-up (Figure 3)

A much more detailed description of methods and problems can be found in Kucera *et al.* (1995), a copy of which is available in the MOELP Library in Victoria.

- Record the location of the sites as outlined above for track-plate stations
- Attach the camera and Infra-red Devices. Some systems come equipped with mounting straps to secure the infra-red devices, and a "tree-pod" for fastening the camera to a tree. You may wish to consider using metal brackets available from a hardware store and a ball-and-socket head for a more adaptable system. It is a good idea to photograph a sign identifying the station as the first image on each roll of film; each roll should be labeled with the station label as well.
- Some cameras offer automatic data collectors that record the date and time of all events, including those that triggered the camera. These devices may provide useful data on patterns of activities.

Field procedures

- Set track plate boxes and remotely triggered cameras at premarked positions.
- Place the track plate boxes with the rear of the box positioned against a tree, log, or other solid object, and covered with branches, leaves, duff, etc.
- Position the box with the open end at a slight downward angle to help prevent rain, snow, etc. from entering.
- Place the bait at the far end of the box. Road-killed moose or deer provide effective and easily obtained bait sources. The Ministry of Transportation and Highways can be contacted to set up a means to collect any road-killed animals. Surplus fish from fish

farms also makes excellent bait and are relatively easy to obtain. Baits will need to be replaced at those stations that have been visited by animals that eat the bait. Old baits and cans must be collected for proper disposal. Canned tuna may be used for bait when other sources are not available.

- Use the same baits for the camera systems as for the track-plates. It is very important that odours from the bait are not transferred to the camera or infra-red equipment; this might result in damage to the camera set-ups by bears and other animals.
- Set stations for a minimum of 12 nights and check every other day, for a total of six visits following set-up. A survey can be terminated early if the species of concern is detected with certainty.
- The track-plates should be checked every other day and the baits renewed as necessary. If tracks of the target species are present on the contact paper, remove it and cover it with one of the original protective sheets. Record the station number and date on the back of the contact paper.
- If there are clear tracks on the soot plate itself, collect and preserve the tracks by placing a strip of wide, clear tape over each print. Press the tape down with a "burnishing tool" of some sort (*e.g.*, a rounded ball-point pen cap). Peel the tape away and apply it to a sheet of heavy, white paper. (Practice this procedure on tracks of non-target species first.)
- If there is adequate soot remaining on the soot plate, simply replace the contact paper. If not, install a fresh soot plate.

Identifying Tracks (Appendix B)

- The prints left on track plates are so different from tracks left in snow, mud, etc. that the traditional field guides (*e.g.*, Murie 1954, Halfpenny and Biesiot 1986) are of limited utility. Taylor and Raphael (1988) provide a guide to some tracks and Zielinski and Truex (1995) give a method for distinguishing between fisher and marten tracks, which can be difficult (Appendix B). Examples of fisher and marten track images can be found in Zielinski and Kucera (1995).
- Not all of the species that may be encountered are included in the track guides cited above. There may be a need to develop a key to identification of species that are encountered in British Columbia. One advantage of the track-plate technique is that tracks can be preserved, and photo-copies can be sent or faxed to authorities when technical help is needed. Table 8 lists species that can be expected to be detected during surveys.
- Have the film processed by one of the large-volume processors which often print duplicate photos for little additional charge. Photos and negatives should be stored together in protective plastic covers.

Table 7. Some species that can be expected to be detected during surveys using track-plates and remotely triggered cameras in British Columbia.

Common Name	Latin Name
Marten	*Martes americana*
Fisher	*Martes pennanti*
Long-tailed weasel	*Mustela frenata*
Ermine (Short-tailed weasel)	*Mustela erminea*
Least weasel	*Mustela nivalis*
River otter	*Lontra (Lutra) canadensis*
Spotted skunk	*Spilogale putorius*
Striped skunk	*Mephitis mephitis*
Raccoon	*Procyon lotor*
Coyote	*Canis latrans*
Snowshoe hare	*Lepus americanus*
Cottontails	*Sylvilagus* sp.
North American Opossum	*Didelphis virginiana*
Shrews	*Sorex* sp.
Voles	*Clethrionomys* and *Microtus*
Lemmings	*Lemmus* and *Synaptomys*
Bushy-tailed Woodrat	*Neotoma cinerea*
Deer mice	*Peromyscus* sp.
Ground squirrels	*Spermophilus* sp.
Chipmunks	*Tamias* sp.
Squirrels	*Tamiasciurus* sp.

Data management and analysis

Track-plate records

Place the contact paper sheets in large 3-ring binders, along with the taped images that have been transferred to sheets of heavy, white paper.

Photographic records

Use large 3-ring binders for storing the data forms and the photos and negatives according to Study Area and station.

Data analysis

In a survey intended to determine presence or absence, the most important information is whether the target species have been detected and whether the evidence comes from track plates or photographs. It will also be important to record the amount of survey effort in terms of track-plate-nights and camera nights, recognizing that these data are not appropriate for analysis as a measure of relative abundance between areas (*i.e.*, “catch-per-unit-effort"). The presence of non-target species should also be recorded.

An analysis of the pattern of detections may help with the design of future surveys. Potentially useful information may include the days within the surveys when the first, second, and other detections occur, the micro-habitat where the detection device was located, weather conditions, etc. This information may help to identify improvements in the procedure.

Other Considerations

The techniques described here regarding remotely triggered cameras or covered track plates have only recently been developed, and consequently, there is much to be learned about their consistent and reliable application. To better understand how these detection systems are working, pay attention to the following:

1. The camera field-of-view in the vicinity of the bait. This should be standardized because many animals that are detected will be ‘captured’ in the periphery of the field. The larger the field-of-view, the greater the ‘capture effort.’
2. The presence of animal tracks at or near detection stations. Look for patterns, for example, Foresman (pers. comm.) noted that a marten approached, but did not enter a track plate cubbie that had been visited by a fisher, possibly because fishers sometimes prey on martens.
3. Time following set-up and causes of camera failures. It is important to understand the causes of failures, with battery failure being the most common. Note battery brand, lots, expire date, etc., along with camera type. Trailmaster, for example, sometimes changes the camera system that it employs in its systems.

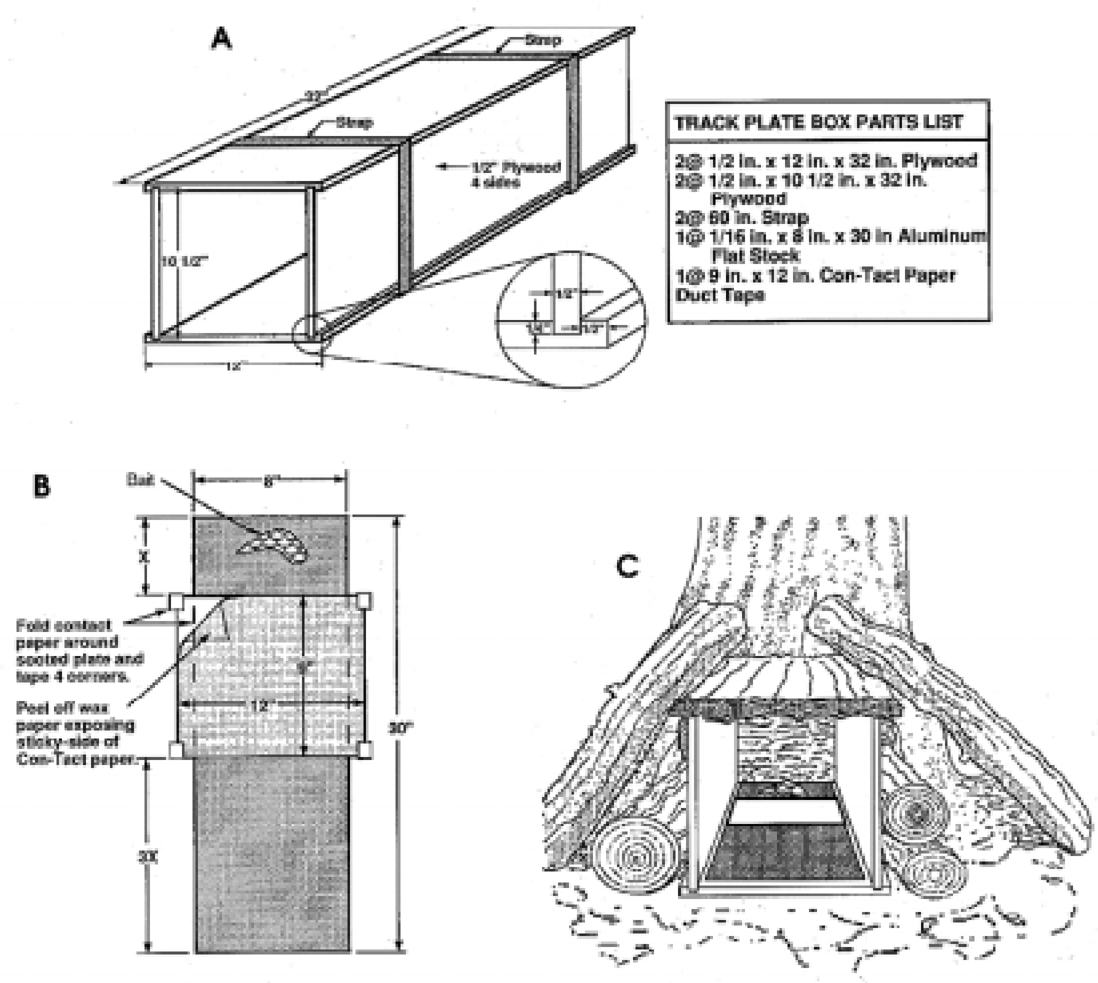

Figure 2. Schematic drawing of track-plate cubby, track-plate, and field set-up.

A. Track-plate cubby and parts list. B. Track plate diagram. C. Field set-up of camouflaged cubby with baited track plate (From Zielinski 1995), or Details of track-plate station (From Fowler and Golightly 1994).

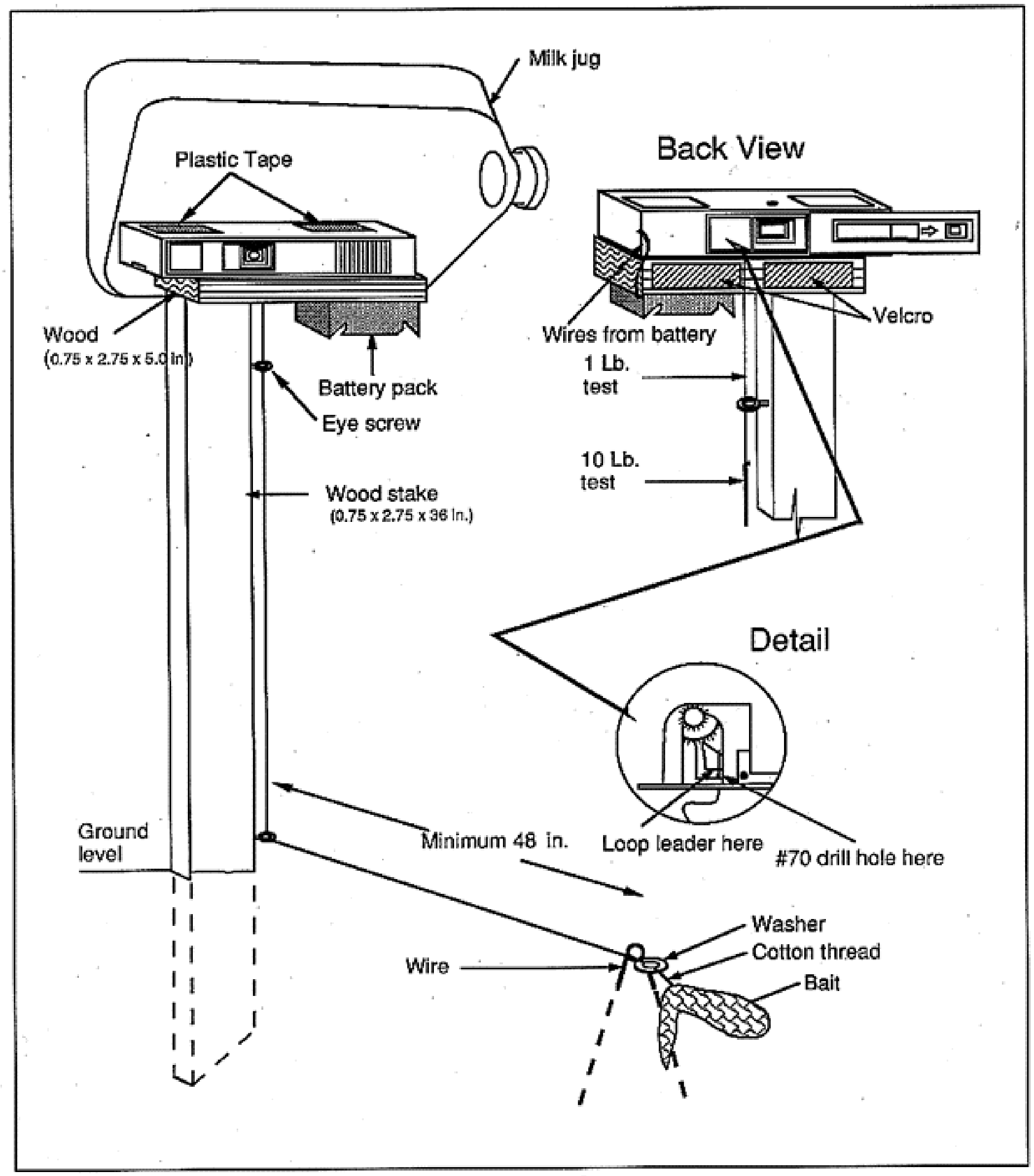

Figure 3A. Remote set-up using a 110 camera and mechanical shutter release system (From Kucera *et al.* 1995).

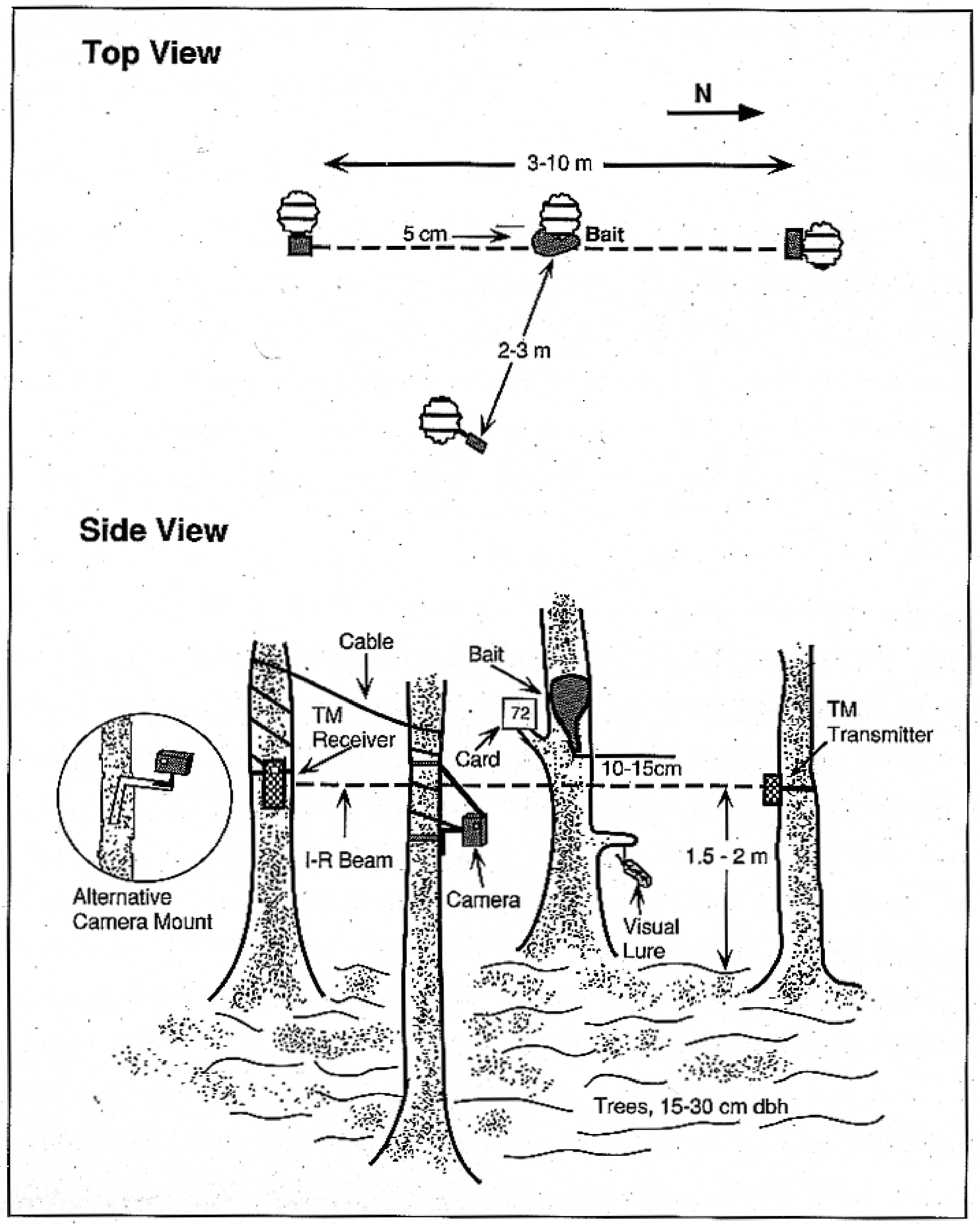

Figure 3B. Remote set-up using an infra-red (I-R) shutter release system using a 35-mm camera.

Figure 3. Schematic diagrams os 110 and 35-mm remotely triggered cameral systems.

Not drawn to same scale (After Kucera *et al.* 1995).

3.4.2 Snow tracking

Snow tracking is a time-honoured means of detecting the presence of wildlife during winter in northern areas. Reading tracks and other sign is part of the stock-in-trade of trappers, hunters, and naturalists, and there is no doubt about its utility in certain situations. The advantages of snow tracking include the fact that snow is widespread in much of British Columbia during winter and consequently, broad areas can be sampled without prior preparation, such as setting-up camera stations or trapping grids. It is also inexpensive and requires minimal technology.

On the other hand, there are a number of problems associated with snow tracking of martens and weasels as a standard inventory method. There are significant parts of the province where snow or suitable snow conditions are not reliably present (*e.g.*, Vancouver Island, coastal regions). Snow conditions are usually best for tracking two to three days following a snowfall, which makes it difficult to schedule field programs. At some times of the year, even when snow is on the ground, crusts, freezing and thawing, etc. can create unfavourable conditions for tracking, and these may vary with time of day, slope, and aspect (Halfpenny *et al.* 1995). It is also difficult to make a permanent record of observations, or to keep a record so that details can be checked to distinguish among tracks of species that can be confused (*e.g.*, marten vs. fisher, and short-tailed vs. least weasel). In addition, there are significant human safety considerations related to winter travel in remote areas.

Snow-tracking is potentially useful with experienced observers and favourable snow conditions. Halfpenny *et al*. (1995) give a thorough discussion of methods and problems, including details on how to identify tracks. The utility of snow-tracking is restricted to determining presence; too many factors can affect mustelid activity to permit snow-tracking to provide a reliable index of population size.

Office procedures

- Review the introductory manual No. 1 *Species Inventory Fundamentals.*
- Obtain maps for project and Study Area(s) (*e.g.*, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Identify objectives and select Project Area. Outline the Project Area on a small to large scale map (1:250,000 – 1:20,000).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the Project Area from maps.
- Delineate one to many Study Areas within this Project Area. Study Areas should be representative of the Project Area if conclusions are to be made about the Project Area. For example, this means if a system of stratification is used in the Sampling Design then strata within the Study Areas should represent relevant strata in the larger Project Area.
- 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/eco-zones of interest. It is a good idea to use start and end points that are easily located on the ground (see Hatler 1991).
- In general, transect lines are selected to sample/compare different habitats within a landscape, but may also be used on a larger scale.

- Select timing of survey. Pre-planning and flexible scheduling are the keys to success in this endeavour. 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

- Lay out transects systematically within Study Areas.
- Transect length may be variable (Slough and Jessup 1984, Gyug 1988) or uniform (Thompson *et al.* 1989) in length; the former is more common to accommodate spatial changes in habitat type. A minimum transect length of 1 km has been recommended (Slough and Jessup 1984). Precision and accuracy generally increase with increasing length of total transects (km-day) within a habitat.

Sampling effort

Gyug (1988) recommended intensive sampling during a short time period (one to two weeks), and set a minimum distance for each habitat type of 10 km-days (distance surveyed in km x days since last snowfall) to provide a sufficient level of effort. Such guidelines are necessary to improve precision of counts when using them to establish an absolute abundance index (Gyug pers. comm.), but more experience with most of the species involved here, in different kinds of habitats, will be required to establish clear recommendations for sampling effort. For example, poor habitat may require higher sampling effort to attain higher precision.

Personnel

Snow tracking is specialty work and experienced observers are required.

Equipment

- Maps (showing transects)
- Snowshoes or skis for transects on foot in deep snow areas
- Snowmobile, if terrain and cover allow its use
- Compass
- Hip chain
- Flagging tape
- Data sheets or hand-held tape recorder (Hatler 1991)

Field Procedure

- 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.
- Data may be recorded as the number of sets of tracks of each species counted along each 100 m segment of the transect, as measured by hip chain or recorded on a snowmobile odometer, or may simply be tallied continuously along the line without reference to segments. Use of a hip chain and tape recorder allows rapid progress along a snow transect with relatively precise measurements to each track crossing, and the resulting data can be assembled in relation to whatever track segment lengths are deemed appropriate (one person method of Hatler 1991).

- Tracking by snowmobile should be done slowly (mean 5 - 10 km/hr) to prevent missing or over-running track incidences.

Data Analysis

Analysis may focus on the occurrence of species' tracks in different habitats, the distribution of these tracks over the Project Area, or the recent use of different habitats as indicated by the number of occurrences of tracks in different habitats. However, any reporting of track abundance should be appropriately qualified with statements about the potentially tenuous relationship between track and animal abundance.

3.5 Relative Abundance

Recommended method(s): No methods recommended.

Functional indices of abundance must exhibit a reasonably consistent relationship with actual abundance over time and/or space. The various indices that might be used to determine changes in relative abundance are too unreliable to be useful. The temptation is great to try to use changes in fur harvest or in track counts, etc. to derive a population index. However, there is currently no method that is sufficiently reliable to measure changes in relative abundance.

3.6 Absolute Abundance

Recommended Method: Mark-recapture. The simple two-stage technique applied by Mace *et al.* (1994) to a grizzly bear population is recommended. In the first stage, marks are applied to live-trapped animals. In the second stage, recaptures or sightings are made using remotely triggered cameras. The analytical model selected will help specify design criteria and the sensitivity of estimates to assumption violations.

3.6.1 Mark-recapture

Martens and weasels are difficult animals to study because of their tendency to be highly variable seasonally and individually in their responses to traps. The individuals within an area also undergo changes in status (*i.e.*, residents vs. transients), apparently as a function of changes in food supply. The method for determining absolute abundance that is described below has not been applied to martens or weasels, and consequently should be considered experimental. This approach depends on being able to mark and recognize individual animals. In contrast to certain other animal groups (*e.g.*, killer whales and giraffes) in which individuals naturally possess individually distinctive marks that can be seen from a distance, it is necessary to actually capture and mark individual mustelids. However, methods for applying a unique mark to a weasel that can be detected photographically have yet been poorly tested. Nonetheless, a somewhat promising technique is described.

The mark-recapture procedure is executed in two stages. Stage 1 is a live-trapping and marking program. This will require capturing and marking either a representative or large portion of the population. Stage 2 is the photographic ‘capture-recapture’ program;, the objective of which is to resample the population, by 1) obtaining recaptures of marked individuals, uniquely identified by the colour code of the ear tags and the location of release, and 2) obtaining captures of unmarked individuals. This operation is independent of the tag application stage.

Martens and weasels have high metabolic rates. When live-captured, they tend to struggle vigorously to escape, and in the process may exhaust themselves and die (referred to as trap myopathy). Wire traps may be provided with wooden "nest boxes" for shelter from weather and refuge. There should be sufficient bait to be a source of food. Dehydration is a significant source of mortality for martens and weasels that are held too long in traps. Traps must be visited daily. When trapping weasels, traps should be visited up to twice daily (if logistically possible) to reduce the number of cases of trap myopathy.

To make any statistic derived from a mark-recapture experiment tractable, a number of assumptions must be satisfied. These assumptions have been presented in various forms and discussed by a number of authors. However, from a practical point of view they amount to the following:

Population closure: It is assumed that the population is closed (*i.e.*, no immigration, emigration, births, or deaths occur), so that the population size does not change over the period of the experiment. For martens and weasels, the population may change in the Study Area over time from mortality, recruitment of young animals, and the movement of itinerants. From a practical estimation viewpoint, the closed population assumption can be completely relaxed if more than 40 percent of the population is marked (refer to life history) (each individual requires a unique mark) for at least four consecutive sampling intervals (capture sessions) and a Jolly-Seber analysis procedure used (Seber 1992). A partial relaxation of the assumption is possible when using the Jolly-Seber model if the following conditions are met: (1) movement of itinerants (recruitment) into the Study Area is negligible in comparison to the overall precision of the study; (2) marked and unmarked animals are equally likely to die or leave the Study Area; and, (3) all marks are applied over a short period of time prior to any recapture effort. However, project biologists should be aware that using the Jolly-Seber methodology will not provide an estimate of population density, as the relaxation of the assumption of closure implies that the size of area sampled is essentially unknown.

Recapture probabilities: It is assumed that the probability of capturing a marked individual at any given time is equal to the proportion of marked members in the population at that time. It is important to note that this assumption relates to the recapture of marked animals in comparison to unmarked animals and not to the application of marks. The problems with respect to sex bias and responses to traps and baits (discussed above) may result in violation of this assumption. One way of confronting this heterogeneity variation is through sampling in a very intensive fashion to reduce the impact of these problems on the population estimate. Seber (1992) recommends the number of animals marked and examined should exceed the population size if problems are suspected. (In other words, the total number of captures and recaptures in both stages of the experiment should exceed the total number of individuals in the population.). Pollock et al (1990, p.24) comment that if the capture probability of the population is above 0.5, the Jolly-Seber model will not be biased by heterogeneity. However, this type of capture probability is generally difficult to achieve, and most investigators have come to the conclusion that heterogeneity in data sets is often inevitable.

Alternatively, the Mh (jackknife) heterogeneous analysis model (Otis *et al.* 1978) can be used to obtain nearly unbiased population estimates, provided that the marked animals exhibit the same heterogeneous capture probabilities as would be found in the entire population (*i.e.*, the marked animals represent a random sample of the population even though subsequent recapture probabilities are heterogeneous). Since this model requires as input the number of animals captured at least once, twice, thrice, and so on, there must be the ability to identify individuals when captured (*e.g.*, a unique code for each marked animal). The heterogeneous model is not available for the fully open population condition, where a Jolly-Seber type estimation procedure might be applied. Researchers should consult the *Species Inventory Fundamentals* for a more detailed discussion of program CAPTURE and closed estimation models.

Lost marks: It is assumed that animals do not lose their marks over the period of the study. The type of mark used and the length of the study are the obvious factors. If marks are lost then the experiment results in over-estimates of population size (termed positive bias) if the

Lincoln-Peterson formula is used for estimates. The reason for this is inherent in the basic Petersen formula:

$$N = CM / R$$

where:

N = estimated size of population
M = number of individuals marked in the first sample (captured)
C = total number of individuals captured in the second sample
R = number of marked individuals in the second sample (recaptured)

If R is believed to be smaller than it really is, N will be calculated to be larger than it should be, thus over-estimating the population size. N is very sensitive to changes in R. Biologists should consult White et al (1983) and Pollock et al (1990) for a more detailed discussion on tag loss.

Missed Marks: All marks are reported (detected) when the animals are recaptured. Recapture techniques in which the animals are not handled (*e.g.*, photographed or observed for a mark from a distance) are the most prone to this problem. Similar to lost marks, missed marks result in an over-estimate of population size, for the same reason (if the Lincoln-Peterson estimator is used).

Office Procedures

Spatial Sampling Layout:

- The sampling grid should cover the entire Study Area. If the habitat is sufficiently homogeneous throughout the region, it may be valid to treat the Study Area as a sample of a larger region and apply the subsequent density estimates to the entire Project Area.
- The spacing of the traps should be based on a minimum of four traps per home range which implies:

  - $$S \leq A / 2$$

  where:

  S = the spacing between stations
  A = the size of the estimated home range

- A spacing of 800 - 1000 m would be typical for martens. Because weasels have highly variable home range sizes, a much wider range of spacing would result (Table 3 implies 25 - 800 m). See the manual *Species Inventory Fundamentals* and White et al (1983) for more details on optimal study design.
- Because home range size varies widely within the same species as a function of food availability and population size, a pilot study (*e.g.*, radio-tracking as described by Katnik *et al.* (1994)) may be required to determine home range size in the absence of adequate information.
- Set out a systematic grid system on a map of the Study Area using the above spacing. As a general rule, if there are fewer than five rows or columns or the sum of the rows and columns is less than 20, then consider abandoning the experiment because this will likely produce a small sample size, resulting in poor levels of precision and accuracy. However, like most general rules, this approach is somewhat simplistic. A more comprehensive approach is for project biologists to consider expected population density in the Study Area. Based on this, they should determine the size of grid needed to ensure a population

of at least 50 individuals as required for program CAPTURE. The number of stations can be determined by the criteria above; however, it may not be possible to make a grid large enough to contain 50 weasels given the lower densities of this animal. Therefore, it may be necessary to consult the literature for capture probability levels from prior studies of marten or weasels. Using this information and program CAPTURE or POPAN 5, it is possible to simulate different population sizes and capture probabilities to determine what type of confidence limits will likely result. If expected confidence limits are too wide then it is necessary to intensify sampling (*i.e.*, more traps or more sampling periods) to get better estimates. If this is not possible due to logistical constraints or if it does not produce the desired results, the experiment should be abandoned..

- If terrain and/or vegetation make it impractical to establish a grid, then layout the sampling sites along roads and trails using the same straight-line spacing distance specified above. If a suitable location for the trap can not be found within the designated area then the trap should not be deployed, and you should proceed to the next location. Keep in mind that this type of transect design will make density estimates impossible, although this may already be the case if a Jolly-Seber model is being used. This transect based approach should only be used when monitoring is the key objective of inventory efforts.

Sampling Design

- The objective of the live-trapping program (Stage 1) is to apply marks to obtain a sample which is as representative of the population of interest as possible, or alternatively, to mark a very large portion of the population. Stations should be close enough to maximize the probability of trapping an animal within a reasonable time. The longer that stations operate and the higher the density of stations, the greater the probability that an animal will visit a trap.
- Ripley (1981) showed that the most efficient sampling design for a spatially contagious distribution (*i.e.*, heterogeneous capture probabilities as in this case) is a grid which is either systematic or non-aligned systematic. Essentially, this means that traps do not have to occur precisely at the grid intersection, but rather, can be placed nearby at a more suitable, random location. For weasels and martens, a non-aligned systematic grid could be achieved simply by placing the live-trap in the most favourable habitat within a specified distance (*e.g.*, 25 percent of spacing distance) of a grid post intersection.
- The biggest drawback of a grid system is the potential difficulty in locating grid intersections and trap locations on the ground. Even with the aid of global positioning devices (GPS), the effort to find and service sampling stations in rugged and heavily canopied terrain may be prohibitive (Golightly, pers. comm.). Where terrain and/or vegetation make a grid impractical, the only alternative is to use a linear transect layout (*e.g.*, a road or trail) and to maximize the application of marks. Once again, note that a transect method will only work for monitoring of populations but will not allow the estimation of population size or density.

Sampling Effort

- With respect to duration of sampling, the prime issue is to minimize violations of the assumption of population closure. Theoretically, the live-trapping and tagging (Stage 1) sequence is presumed to be instantaneous, with all marks applied instantly and therefore no concurrent change in the population (no itinerants, mortality, emigrants, or immigrants). To best meet this assumption, Stage 1 is to be completed as quickly as possible. It is estimated that live-trapping operations will last five days and mark a minimum of 25 animals. However, trapping success (catch per unit effort) will vary with the species and region of study.

- After all marks are applied, the population size can change, but itinerants and emigrants are presumed not to exist. Thereafter the remote camera operation may be more relaxed, and sampling can occur over several weeks (until significant immigration into the area occurs) if the Jolly-Seber open model is used for analysis.

Personnel

- Anyone attempting to proceed with a live-capture research initiative should be familiar with trapping protocol in British Columbia (see manual no. 3, *Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians & Reptiles*). Furthermore, if immobilization is part of the study protocol, then crew leaders must be certified to legally acquire drugs and immobilize wildlife in British Columbia.

Equipment

- Camera and film (slide or print). It is recommended that a lens with macro capabilities be used to get close up shots of the species being photographed.

- <u>Live traps for martens</u>
  - Baited wire traps, such as Model 205 Tomahawk Traps (Tomahawk Live Trap Company, Tomahawk, WI), are effective in capturing martens (Fowler and Golightly 1994, Lofroth, pers. comm.).
  - Add a plywood box with a sliding door (Figure 4) to the trap to provide a dry, dark shelter. Without the cover, martens may injure themselves attempting to escape or may suffer from exposure. Weir *et al.* (pers. obs. 1998) use wax-coated cardboard boxes to cover all sides of the traps. Sub-alpine fur boughs can then placed on the top, sides, and back of the trap to provide further insulation from wind and moisture.
  - Provide hay inside the trap (for the mustelid to build a nest) which will further enhance the insulative qualities of the trap design. This trap design method allows for insulation from wind and moisture, while simultaneously providing a dark, natural den-like setting.
  - Provide a large quantity of food (>500 g) in the traps (Bull *et al.* 1996).
  - Electronic trap monitors, such as those manufactured by Telonics, may be helpful by permitting traps to be monitored remotely. However, despite their apparent convenience, electronic trap monitoring devices will not provide any information on trap status (*i.e.*, is the trap trigger mechanism frozen or jammed?). Ultimately, this could influence catch-per-unit-effort calculations.
- <u>Anaesthetic for martens</u>
  - Anaesthetic: ketamine and diazepam (200 mg:1 mg), ketamine hydrochloride and xylazine hydrochloride (2:1 mixtures), or telazol (tiletamine and zolazepam).
- <u>Live-traps for weasels</u>
  - Use a wooden or wire live trap. These traps need to have a smaller mesh size than those used for martens to reduce the possibility of escape.
- <u>Anaesthetic for weasels</u>
  - Edgar and King (1977) used ether introduced into a wooden live trap to anesthetise weasels. They also suggest that it may be desirable to devise an anaesthetizing chamber that could be carried in the field, if it appeared that lingering ether odours in

the trap inhibited further captures. In the case of wire traps with attached wooden boxes, it may be possible to bubble ether into the box.

- Marking martens & weasels
  - Ear tags and tattoos have been used on some martens and weasels.
  - Fowler and Golightly (1994) report good success using modified Rototags (Dalton / Nasco, Ft. Atkinson, WI), with six different colours of tape. The tags were shortened to 15 mm by removing the distal 20 mm. They glued coloured reflective tape (3M Scotch Brand, St. Paul, MN) to the tag using Super-Glue (Duro, Loctite Corp., Cleveland, OH).
  - Coloured collars, similar to those used for radio collars but without the radios, might also be used to visually mark individual martens or weasels. Collars should contain a segment of cotton or other degradeable material that will deteriorate over several months and eventually free the marked animal (so that it will not be burdened with a collar for the rest of its lives).
  - It might be possible to use dyes to mark weasels in those parts of their range where they turn white in winter (*i.e.*, the Interior).
- Remote Camera Equipment
  - See section 3.4.1 Detection Devices under heading Equipment for camera equipment.

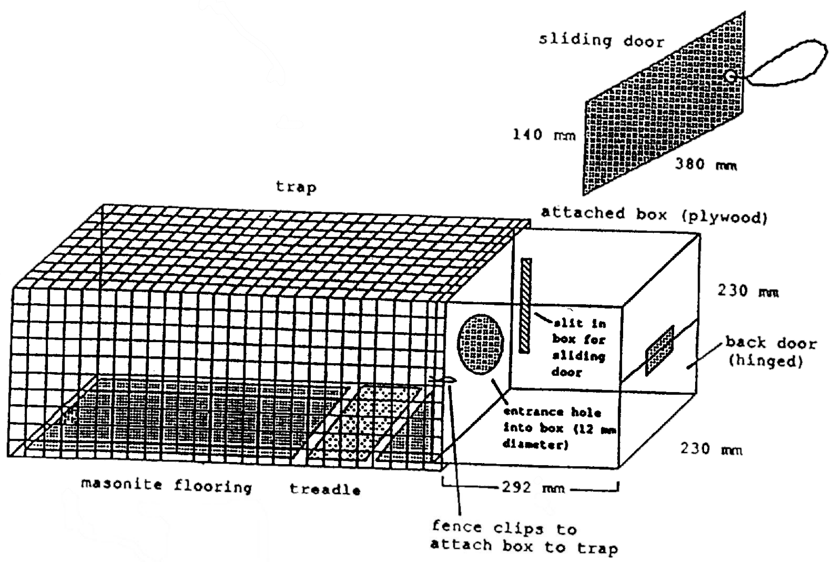

Figure 4. Details of trap and plywood refuge and shelter box. (From Fowler and Golightly 1994)

Field Procedures

Set-up

Timing:

- Of the factors that affect capture probabilities, time is the one most easily controlled by the biologist, who can select both the season when field work is conducted and the length of the sampling period. In both of these decisions, the objective is to maximize capture-recapture efficiency and to reduce variation in capture probabilities over time. The entire program should be conducted in late-winter (February-March).
- There are seasonal changes in catchability driven by many factors including prey or food availability, active predator population, reproductive status and weather, which may effect mobility and propagation of odours from baits. Raphael (1994) found that martens in Wyoming were two to three times more difficult to trap in summer than in other seasons. In late winter, mustelid populations are smallest, with a tendency for the survivors to be residents, with a smaller number of transients. Reduced prey populations may increase the attractiveness of baits, and thus result in increased trappability. Another factor to consider is seasonal mobility of the sampling crew. For example, snowmobiles can provide rapid transport in late winter over terrain not possible any other time of the year. For these reasons we recommend that the sampling be focused on the late winter period (February-March), when snow conditions and day length are also favourable.

Station spacing:

- See **Field Procedures**

Grid size:

- Grid size can be approximated for martens by noting that Seber (1982) recommends marking at least 25 animals for a simple 2-stage Petersen experiment assuming that recapture effort will be extensive. Raphael (1994) cites historical literature for a winter live-trapping rate of about 3.4 per 100 trap-nights in British Columbia. Using this trapping rate, 147 traps would be required to trap 25 marten over five nights (735 trap-nights). Following the same example, the best sampling geometry would be a 12 by 12 grid of 144 traps, spreading effort over the maximum area (square). This would be consistent with Otis *et al.* (1978) who recommend that the minimum number of rows or columns of a sampling grid should exceed four and the sum of rows and columns should exceed 19 (thus, a minimal rectangular grid might be 5 by 15, or a square grid might be 10 by 10).
- Obviously, the example above is a hypothetical situation. Ultimately, dimensions are not the chief constraint in grid design, but rather sampling should reflect expected density and capture probability. As well, in a real inventory project, one must take into consideration the time necessary for deploying traps, the number of qualified workers available to check traps, and the latency to first detection (see Foresman and Maples 1997). Also, it is very unlikely that 25 animals would be captured in a five day live-trapping session.

Capture:

- Live trap the animals. Make sure traps are checked at least once daily to ensure that the animals do not become dehydrated (Bull *et al.* 1996).
- Transfer trapped animals to an animal handling cone.

- Anaesthetize marten
  - While in the handling cone, the martens can be anaesthetized with ketamine and diazepam (200 mg:1 mg), administered at a rate of 0.022 mg / 100 g body weight for males; 0.026 mg / 100 g body weight for females. These dosages were determined empirically by Fowler and Golightly (1994), and might need to be adjusted for British Columbia martens. Lofroth (1993) used a 2:1 mixture of ketamine hydrochloride and xylazine hydrochloride (both 100 mg/ml) at a combined dosage of 2 mg/100g body weight. Bull *et al.* (1996) mention the use of Telazol (Tiletamine and Zolzepam; Fort Dodge Labs, Inc., Fort Dodge, IA 50501) to immobilize marten at a dosage of 8 mg/kg. In British Columbia, it is required that individuals become certified in the chemical immobilization of wildlife prior to commencing a live capture program that involves anaesthetizing animals.
  - The anaesthetized martens should be weighed, sexed, aged, and photographed. The weights can be determined approximately by weighing the marten in the cone and subtracting the cone weight. Photographs should be taken of the dorsal and ventral surfaces, of the lateral surfaces and of the face and head. Unusual or identifiable marks or features should also be photographed. Photographs of the pelage (particularly the throat patch) of martens may prove to be useful when attempting to identify martens at camera stations, or in the case of a recapture. It may be useful to have an item of scale in the photographs.
- Anaesthetize weasel
  - Edgar and King (1977) used ether introduced into a wooden live trap to anesthetise weasels. They also suggest that it may be desirable to devise an anaesthetizing chamber that could be carried in the field, if it appeared that lingering ether odours in the trap inhibited further captures. In the case of wire traps with attached wooden boxes, it may be possible to bubble ether into the box. King and Edgar state that "The usual response (to the ether) is as follows: first the stoat closes its eyes, sneezes, and shakes its head; then, as it begins to lose coordination, it breathes faster; in the final stage it completely collapses and its breathing slows down again. It is seldom unconscious for more than two to three minutes, and usually recovers within 10 minutes. Two light doses are better than one heavy one, because it is easy to over-anaesthetize."
  - Zielinski and Powell (pers. comm.) shook *M. erminea* into pillow cases and restrained them physically while they ear-tagged them. Zielinski (pers. comm.) goes on to state that this procedure could be done by one person within a matter of minutes.
  - The anaesthetized weasels should be weighed, sexed, aged, and photographed. The weights can be determined approximately by weighing the weasel in the pillow case and subtracting the pillow case weight. Photographs should be taken of the dorsal and ventral surfaces, of the lateral surfaces and of the face and head. Unusual or identifiable marks or features should also be photographed. Photographs of the pelage (particularly the throat patch) of weasels may prove to be useful when attempting to identify martens at camera stations, or in the case of a recapture. It may be useful to have an item of scale in the photographs.

- Marking martens
  - Individual martens can be marked using ear tags (modified Roto-tags) or collars marked with coloured reflective tape, although both of these means should be considered experimental at present.

    - Fowler and Golightly (1994) report good success using modified Rototags (see Equipement section). Tags should be placed in both ears to improve the chance that tagged animals are recognized in photographs and to provide a back-up mark in case one is lost.
    - Coloured break-away collars might also be used to visually mark individual martens (see Equipment section). When fitting a collar to a marten, be aware that if it is too tight, it can restrict breathing, and one that is too loose will simply be pulled off. If your little finger fits comfortably between the collar and the marten's neck, the collar is sufficiently sized.
- <u>Marking weasels</u>
    - It is unlikely that a collar fitted to any of the weasels would be large enough to permit easy identification of individuals at a distance. However. It may be possible to place coloured plastic collars on weasels for identification through a mark/re-capture program.
    - The literature does not identify means of uniquely marking weasels for visual re-identification. Ear tags that would be large enough to be reliably detectable photographically are too large to use on these species.
    - For weasels, which turn white in winter throughout the colder parts of their range (*i.e.*, most of the British Columbia Interior), it may be possible to use coloured hair dye applied in bands around the body. It should be possible to use several colours, two at a time to achieve a large number of unique combinations. The number of unique combinations could be doubled by reversing the order of the colours (*e.g.*, black in front of red on one animal, red in front of black on another). Such colour marks would last only until the next moult, but this may not be problematic for population estimates that are made in a short period of time. Whether colour marks would affect hunting success or vulnerability to predation is unknown.
    - In addition to colour marks, small metal or plastic ear tags, or tattoos should be applied to captured individuals. Choose ear tag colour combinations so that each individual being marked receives a unique combination. Record the ear tag combination on a field data form.
- Determining a loss rate would be important in a project intended to estimate population size.
- If a marked animal is re-captured in a live-trap, it should be released immediately with a minimum of stress, and the trap should be removed or deactivated. If certain individual martens repeatedly enter traps, it may be necessary to suspend trapping for a few days so that those martens do not suffer fatal effects of trap captivity. Weir *et al.* (Hawkes pers. obs. 1998) are providing a small amount of strawberry jam on the end of a stick for each marten that is captured (or recaptured) prior to its being released. This is done to increase the martens blood sugar level, as one cause of trap myopathy has been found to be stress related hypoglycemia. The animals readily lick the jam from the end of the stick, and are subsequently released.

Resight or Recapture

<u>Remote Cameras:</u>

- The same stations used for live-trapping can be used for the remote cameras. However, only half the sites are needed. These sites should be randomly selected (*e.g.*, flip a coin or use a random numbers table).

- See section 3.4.1 Detection Devices under heading Field procedures for remote camera set-up.
- Because an individual may visit a photo-station more than once in a 24-hour period, it is necessary to define what constitutes a "capture" and "recapture."
  - A recapture is a photograph or photographs of a marked individual taken in the 24 hours between noon of one day and noon of the next.
  - A capture is a photograph or photographs of an unmarked individual taken between noon of one day and noon of the next. In the latter case, it is assumed that it is unlikely that more than one individual will visit a given photo-station in a 24-hour period. This assumption should be tested using the recapture pattern of uniquely marked individuals.

<u>Record the following information on the dataforms:</u>

- Detection method used to capture sample (live-trap or camera). This indicates whether the captured animal was taken in a live-trap or was only photographed.
- Station (location) label. Each station in the grid must have an unique identification label.
- Marking: enter ‘NO’ if the photo was of an animal without a mark, ‘YES if it had a mark. Record tag colours and unique tag ID code. If the captured animal is from a live-trap, this field can be left blank or the entry can be made consistent with the site location and tag colours. If the animal is photographed and has a tag, then the unique animal ID can be deduced from the tag colours and recapture location if colour combinations were reused.
- Date of capture or recapture.
- Animal condition code or Health (*i.e.*, alive or dead).

Data Analysis

- Data can be entered electronically into a mark-recapture standardized format using data-entry programs in the POPAN-2 system (Arnason and Baniuk 1978). The mark-recapture data should be held as a separate record for each animal captured or recaptured.
- While this 2-stage design is simple it is also ingenious because less onerous assumptions are required. The closure assumption can be relaxed if the movement of itinerants (recruitment) into the Study Area is negligible in comparison to the overall precision of the study; and, marked and unmarked animals are equally likely to die or leave the Study Area. Unfortunately, it is difficult to test whether the recruitment or emmigration into the study area is marginal compared to study precision without the use of radio-collared animals. Pollock's robust design (as discussed in *Species Inventory Fundamentals*) can be suitable if population density and monitoring are objectives of the project, as this robust design can detect temporary emigration from the trapping area.
- It can be useful to use the capture probability tests in program CAPTURE to screen the data for heterogeneity, time, or behavior variation before selecting an appropriate model.
- Several models are suggested.
  - If indistinguishable (*i.e.*, non-unique) marks are used then animals are sampled with replacement (the same animal can be observed more than once) and analysis can proceed with Bailey's binomial model employing a bias correction factor to compensate for small sample size (Eberhardt 1990).
  - If individuals can be distinguished in the recapture photos (*e.g.*, colour bands in an ear tag or radio collar) then it is suggested that biologists use the program

MARK. Program MARK includes all the closed population estimators from program CAPTURE, as well as Jolly-Seber open population estimators. MARK allows rigorous comparison of models using a variety of statistical techniques. It allows testing of hypotheses regarding different segments of the population and determination of population change over time. MARK is limited in terms of providing population estimates for open model estimators. For this purpose, programs POPAN5, JOLLY, and JOLLYAGE should be used.

  - If sample size becomes too small (sparse recaptures) and/or Bayesian posterior probabilities for population estimates are desired, methods described by Gazey and Staley (1986) can be used. If this approach is chosen, it will almost certainly require consultation with a biometrician who is familiar with Bayesian statistics.
  - For more information on mark-recapture software, consult *Species Inventory Fundamentals*. It is also suggested that a statistician be consulted if biologists are not familiar with mark-recapture theory.

- An important criterion for choosing the analytical approach for estimating the population size is whether the recaptures of individuals are heterogeneous. Therefore, a goodness-of-fit test must be conducted under the null hypothesis that the recapture frequencies are binomial in distribution. The other criterion is the size of the sample that can be classified in relation to the total number of recaptures. This is one of the many capture probability tests in the program CAPTURE model selection routine.
- The following sections on design draw from Raphael (1994) and restrictions imposed by the recommended analytical model.

$$S \leq W / 2$$

where
S = the distance between stations
W = the radius of the home range.

- For example, animals with a home range of 10 km^2, spacing would be approximately 0.9 km to assure four stations per home range. Because home ranges of males are larger that those of females, optimal spacing for one sex may not be optimal for the other. Placing multiple stations within the home range of an animal increases the probability of detection at the risk of decreased independence of observation (Raphael 1994). The issue of ensuring independence may become secondary, however, if it is difficult to obtain an adequate sample size. As well, although differential trapability may be expressed as heterogeneity variation in the data, this can be accommodated by using a heterogeneity model in program CAPTURE.
- If the marks applied to a given number of animals (samples) are viewed as a representative sample of the population and unique marks can be identified, then the camera stations (Stage 2) can use the same sites established for the live-traps. Analysis could proceed with the heterogeneous model. Moreover, fewer camera stations are required because they can be operated for a longer period without violation of the closure assumption. If there is a systematic bias in the application of marks then the recapture sequence with cameras must be made to be independent of the mark application sequence. A convenient strategy is to randomly select half the live-trap sites.

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.

ACCURACY: A measure of how close a measurement is to the true value.

BIODIVERSITY: Jargon for biological diversity: "the variety of life forms, the ecological roles they perform, and the genetic diversity they contain" (Wilcox, B.A. 1984 cited in Murphy, D.D. 1988. Challenges to biological diversity in urban areas. Pages 71- 76 *in* Wilson, E.O. and F.M. Peter, Eds. 1988. Biodiversity. National Academy Press, Washington, D.C. 519 pp.).

BLUE LIST: Taxa listed as BLUE are sensitive or vulnerable; indigenous (native) species that are not immediately threatened but are particularly at risk for reasons including low or declining numbers, a restricted distribution, or occurrence at the fringe of their global range. Population viability is a concern as shown by significant current or predicted downward trends in abundance or habitat suitability.

CBCB (Components of B.C.'s Biodiversity) Manuals: Wildlife species inventory manuals that have been/are under development for approximately 36 different taxonomic groups in British Columbia; in addition, six supporting manuals.

COSEWIC: Abbreviation for the the Committee on the Status of Endangered Wildlife in Canada. It is a committee of representatives from federal, provincial and private agencies which assigns national status to species at risk in Canada. COSEWIC is composed of representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Museum of Nature, Canadian.)

CREPUSCULAR: Active at twilight

DESIGN COMPONENTS: Georeferenced units which are used as the basis for sampling, and may include geometric units, such as transects, quadrats or points, as well as ecological units, such as caves or colonies.

DIURNAL: Active during the daytime

EWG (Elements Working Group): A group of individuals that are part of the Terrestrial Ecosystems Task Force (one of seven under the auspices of RIC) which is specifically concerned with inventory of the province's wildlife species. The EWG is mandated to provide standard inventory methods to deliver reliable, comparable data on the living "elements" of British Columbia's ecosystems. To meet this objective, the EWG is developing the CBCB series, a suite of manuals containing standard methods for wildlife inventory that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species populations.

INVENTORY: The process of gathering field data on wildlife distribution, numbers and/or composition. This includes traditional wildlife range determination and habitat association inventories. It also encompasses population monitoring which is the process of detecting a demographic (*e.g.* growth rate, recruitment and mortality rates) or distribution changes in a population from repeated inventories and relating these changes to either natural processes (*e.g.* winter severity, predation) or human-related activities (*e.g.* animal harvesting, mining, forestry, hydro-development, urban development, etc.). Population monitoring may include the development and use of population models that integrate existing demographic information (including harvest) on a species. Within the species manuals, inventory also includes, species statusing which is the process of compiling general (overview) information on the historical and current abundance and distribution of a species, its habitat requirements, rate of population change, and limiting factors. Species statusing enables prioritization of animal inventories and population monitoring. All of these activities are included under the term inventory.

MARK-RECAPTURE METHODS: Methods used for estimating abundance that involve capturing, marking, releasing, and then recapturing again one or more times.

MONITOR: To follow a population (usually numbers of individuals) through time.

NOCTURNAL: Active at night

OBSERVATION: The detection of a species or sign of a species during an inventory survey. Observations are collected on visits to a design component on a specific date at a specific time. Each observation must be georeferenced, either in itself or simply by association with a specific, georeferenced design component. Each observation will also include numerous types of information, such as species, sex, age class, activity, and morphometric information.

POPULATION: A group of organisms of the same species occupying a particular space at a particular time.

PRECISION: A measurement of how close repeated measures are to one another.

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 for species generally takes place within smaller, representative Study Areas so that results can be extrapolated to the entire Project Area.

PROJECT: A species inventory project is the inventory of one or more species over one or more years. It has a georeferenced boundary location, to which other data, such as a project team, funding source, and start/end date are linked. Each project may also be composed of a number of surveys.

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

RED LIST: Taxa listed as RED are candidates for designation as Endangered or Threatened. Endangered species are any indigenous (native) species threatened with imminent extinction or extirpation throughout all or a significant portion of their range in British Columbia. Threatened species are any indigenous taxa that are likely to become endangered in British Columbia, if factors affecting their vulnerability are not reversed.

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.

RIC (Resources Inventory Committee): RIC was established in 1991, with the primary task of establishing data collection standards for effective land management. This process involves evaluating data collection methods at different levels of detail and making recommendations for standardized protocols based on cost-effectiveness, co-operative data collection, broad application of results and long term relevance. RIC is comprised of seven task forces: Terrestrial, Aquatic, Coastal/Marine, Land Use, Atmospheric, Earth Sciences, and Cultural. Each task force consists of representatives from various ministries and agencies of the Federal and British Columbia governments and First Nations. The objective of RIC is to develop a common set of standards and procedures for the provincial resources inventories. [See http://www.for.gov.bc.ca/ric/]

SPI: Abbreviation for ‘Species Inventory’; generally used in reference to the Species Inventory Datasystem and its components.

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 taxonomic group for one season.

SURVIVORSHIP: The probability of a new-born individual surviving to a specified age.

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

TERRESTRIAL ECOSYSTEMS TASK FORCE: One of the seven tasks forces under the auspices of the Resources Inventory Committee (RIC). Their goal is to develop a set of standards for inventory for the entire range of terrestrial species and ecosystems in British Columbia.

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

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Appendices

Appendix A- List of persons interviewed

Bowser, A., Wildlife Technician, Tiberius Wildlife Consulting, Williams Lake, BC.

Buskirk, S.W., Department of Zoology, University of Wyoming, Cheyenne, WY.

Doyle, D., Wildlife Branch, BC Ministry of Environment, Lands and Parks, Nanaimo, BC.

Forbes, R., Wildlife Branch, BC Ministry of Environment, Lands and Parks, Surrey, BC.

Gilbert, J.R., Wildlife Department, University of Maine, Orono, ME.

Golightly, R.T., Department of Wildlife, Humboldt State University, Arcata, CA.

Hatler, D.F., Biologist and Trapper, Smithers, BC.

Jones, L.L.C., US Forest Service, Pacific Northwest Research Station, Olympia, WA.

Lofroth, E.C., Wildlife Branch, BC Ministry of Environment, Lands and Parks, Victoria, BC.

Powell, R.A., Department of Zoology, North Carolina State University, Raleigh, NC.

Raphael, M.G., US Forest Service, Pacific Northwest Research Station, Olympia, WA.

Saunders, B., Wildlife Branch, BC Ministry of Environment, Lands and Parks, Victoria, BC.

Weir, R.D., Wildlife Biologist, Artemis Wildlife Consultants, Westwold, BC.

Zielinski, W.J., US Forest Service, Pacific Southwest Research Station, Arcata, CA.

Appendix B. Guides to Identification of Mammal Track Images Left on Track-Plates and a Means of Discriminating Between Marten and Fisher Track Images.

A three-variable function involving the width of the center palm pad (I3), the length of center palm pad (I3), and the length of lateral palm pad (I4) (Figure 5), is recommended to classify unknown tracks suspected to be either marten or fisher collected from contact paper (Zielinski and Kucera 1995).

If (4.595*width I3) + (3.146*length I3) + (0.0906*length I4) - 80.285 > 0, classify the track as fisher; if < 0, classify the track as marten .

Description of the discriminant function (Zielinski and Kucera 1995).

Before toe and interdigital pads are identified, it is necessary to know whether the track was made by the right or left foot. This can be assessed by the following rules. The medial-most digit (the “thumb”; 1 in Figure 5) is generally smaller and posterior to the remaining toe pads and is often even with the largest interdigital pad. A small metacarpal pad (I1) is posterior and lateral to the “thumb”, quite close to the main interdigital pads (I2, I3, and I4). The “thumb” (1) and the metacarpal pad (I1) are on the medial side of the track. Thus, if they are on the left side of the track, the track is from a right foot. When both pads are lacking, the location of a heel pad (H), present on forefoot only, is used to determine left or right foot. This pad is posterior to the interdigital pad and is angled such that its anterior margin is directed toward the lateral (outside) portion of the track. If none of the above indicate left or right foot, the relative location of the outermost toe pad (5 in Figure 5) and the lateral to the “thumb” (2) was assessed. In general, pad 5 is smaller than pad 2, and its anterior margin is posterior to that of pad 2. Once left or right foot is established, identify toe pads as 1, 2, 3, 4, 5 (medial to lateral), and a metacarpal pad, I1. The heel pad, if present, is identified as H (Figure 5).

To create a reference point (the origin of a Cartesian grid superimposed on the track): draw two lines, one connecting the medial margins of 2 and I3 and the other connecting the lateral margins of 5 and I3. Bisecting this angle creates the ordinate, and a line drawn perpendicular to it at the anterior margin of I3 creates the abscissa (Figure 5).

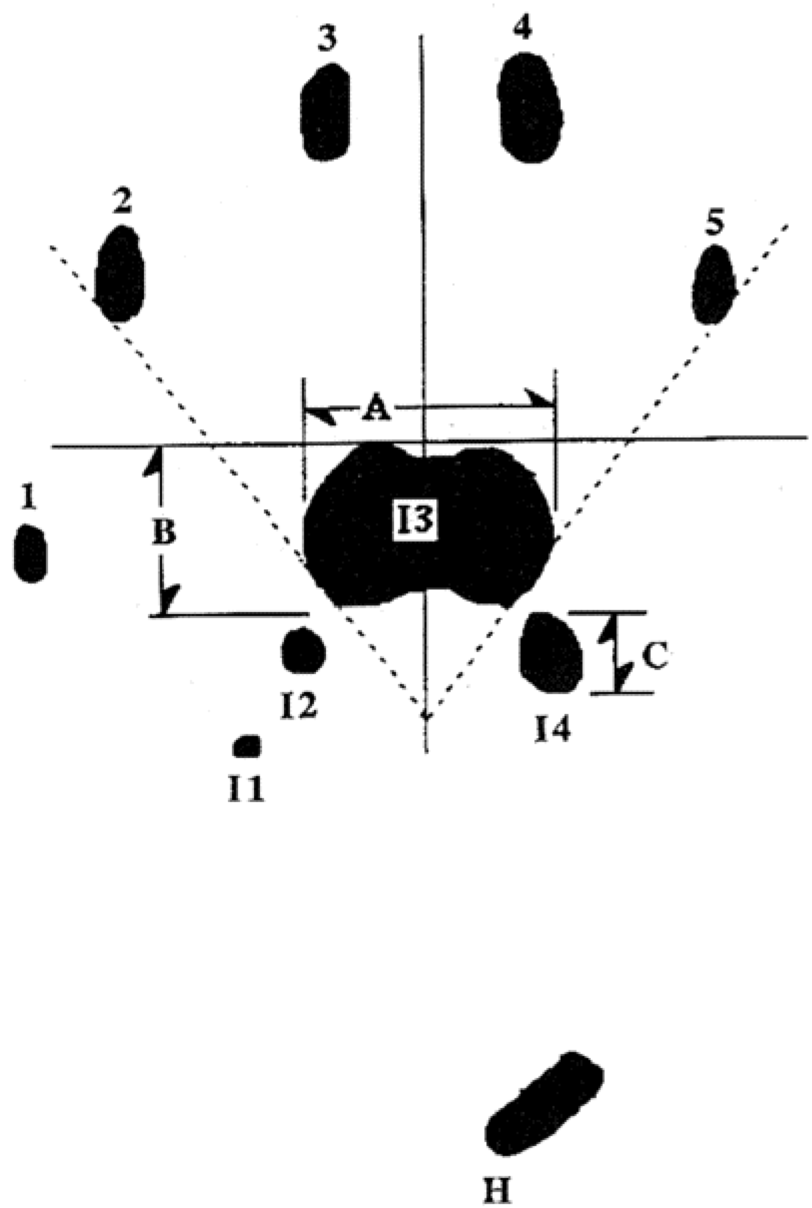

Figure 5. A schematic diagram of right marten or fisher forefoot track collected from sooted track impressions, as a guide to discriminating between Marten and Fisher track images (From Zielinski and Kucera 1995).

Toe pads are identified with numbers (1-5) while interdigital pads and the heel pad are represented with letters (I1-I4, H). The ordinate of the Cartesian grid is formed by bisecting the angle of intersection created by lines joining the medial margins of 2 and I3 and the lateral margins of 5 and I3. A is the width of I3, B is the length of I3, and C is the length of I4.