Inventory Methods for Pikas and Sciurids:

Pikas, Marmots, Woodchuck, Chipmunks and Squirrels

Standards for Components of British Columbia's Biodiversity No.29

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Ministry of Environment, Lands and Parks
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Preface

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

This manual is one of the Standards for Components of British Columbia's Biodiversity (CBCB) series which present standard protocols designed specifically for group of species with similar inventory requirements. The series includes an introductory manual (*Species Inventory Fundamentals No. 1*) which describes the history and objectives of RIC, and outlines the general process of conducting a 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 species 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/

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

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

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Terrestrial Ecosystems Task Force

All decisions regarding protocols and standards are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this document are based on Version 1.1 of this manual and the unpublished government report, *Standardized Methodologies for the Inventory of Components of Biodiversity: Pikas and Sciurids*, prepared for the Resources Inventory Committee by Pontus M.F. Lindgren and Thomas P. Sullivan of Department of Forest Sciences, Faculty of Forestry, University of British Columbia, with reviews and support from Maria Leung, Douglas Ransom, and Shelley Allen. The current version of this manual includes a more rigorous data analysis and survey design section based on review comments from John Boulanger (Integrated Ecological Research) and Dr. Charles Krebs (UBC).

The Standards for Components of British Columbia's Biodiversity series is currently edited by James Quayle with assistance from Leah Westereng.

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1. INTRODUCTION

The inventory group that will be discussed in this report includes all of the species of pikas (Order Lagomorpha; Family Ochotonidae) and sciurids (Order Rodentia; Family Sciuridae) found in British Columbia. This group includes 16 species sciurids (squirrels) including chipmunks, ground squirrels, marmots, and three different genera of tree squirrels and two species of pikas (Table 1).

There are considerable differences in the biology and ecology of these animals. Some hibernate; others are active year round. Body sizes range from chipmunk to marmot size (40-g to 13-kg). Some are monoestrus; others are polyoestrus. Some are colonial; others are solitary. Preferred habitats range from alpine to valley bottom and dense forests to open grasslands. However, within this inventory group most species are diurnal, are easily visible, are herbivorous, have conspicuous vocalizations, and many leave evidence of their presence in the form of some type of physical sign. These similarities make it a useful group to discuss collectively with respect to the methods used for their inventory. A summary of the current knowledge of these animals' biology and ecology is given in section 2.

Measures of biodiversity can be obtained from three different levels of inventory: presence/not detected, relative abundance, and absolute abundance inventories. Data collection and analysis methods are described for each level of inventory in section 3.0 Protocols. Included in this section are details on the office and field preparation, personnel expertise, and field equipment required to perform a given sampling method. In addition, this section discusses the advantages and disadvantages associated with each of the recommended methods.

2. INVENTORY GROUP

The 18 pikas and sciurids found in British Columbia are listed in Table 1, followed by a detailed description of each species.

Table 1. List of pikas and sciurids found in British Columbia[a]

Common Name	Scientific Name	Species Code
Order Lagomorpha, Family Ochotonidae		
Common Pika	*Ochotona princeps*	M-OCPR
Collared Pika	*Ochotona collaris*	M-OCCO
Order Rodentia, Family Sciuridae		
Columbian Ground Squirrel	*Spermophilus columbianus*	M-SPCO
Arctic Ground Squirrel	*Spermophilus parryii*	M-SPPA
Golden-Mantled Ground Squirrel	*Spermophilus lateralis*	M-SPLA
Cascade Mantled Ground Squirrel	*Spermophilus saturatus*	M-SPSA
Yellow-bellied Marmot	*Marmota flaviventris*	M-MAFL
Woodchuck	*Marmota monax*	M-MAMO
Hoary Marmot	*Marmota caligata*	M-MACA
Vancouver Island Marmot	*Marmota vancouverensis*	M-MAVA
Yellow-pine Chipmunk	*Tamias amoenus*	M-TAAM
Least Chipmunk	*Tamias minimus*	M-TAMI
Townsend’s Chipmunk	*Tamias townsendii*	M-TATO
Red-tailed Chipmunk	*Tamias ruficaudus*	M-TARU
Red Squirrel	*Tamiasciurus hudsonicus*	M-TAHU
Douglas’ Squirrel	*Tamiasciurus douglasii*	M-TADO
Northern Flying Squirrel	*Glaucomys sabrinus*	M-GLSA
Gray Squirrel	*Sciurus carolinensis*	M-SCCA

[a]Campbell and Harcombe (1985)

2.1 Common Pika, *Ochotona princeps* (Richardson)

Synonyms

Ochotona fenisex, O. nigrescens, O. uinta, O. levis, O. taylori, O. albatus, O. figginsi, O. cinnamonea, O. saxatilis, O. cuppes, O. minimus, O. schisticeps, Lagomys schisticeps, L. minimus, and *L. princeps* (Smith and Weston 1990; Nagorsen 1990), or *Ochotona alpina* complex (Weston 1982).

Other common names

Pika (Nagorsen 1990), American pika, Southern pika, hay-maker (Smith and Weston 1990), Rocky Mountain pika, rock rabbit (Cowan and Guiguet 1973), cony or rock cony, whistling hare, piping hare (Whitaker 1988), or mouse hare (MacDonald and Jones 1987).

Distribution within British Columbia

The Common Pika is found within the southern half of the province. More specifically, three of the nine subspecies of the Common Pika (*Ochotona princeps littoralis, O. p. brunnescens,* and *O. p. fenisex*) are located within the south-western corner of the province, north to Bella Coola, along the coastal slope of the Coastal Range Mountains, and inland to the eastern slope of the Cascade Range and western sections of the Chilcotin plateau. The subspecies *O. p. brooksi* is restricted to the Shuswap Lake area, *O. p. saturata* to Wells Gray Provincial Park, *O. p. septentrionalis* to the Itcha Mountains, and *O. p. cuppes* to the Monashee and Selkirk Ranges of the province. The final two subspecies of the Common Pika (*O. p. princeps and O. p. lutescens*) are found along the eastern border of British Columbia, within the Rocky Mountains, north to Mount Robson and south into Montana (Cowan and Guiguet 1973; Banfield 1974; Nagorsen 1990).

Ecoregions: Coastal Gap, Fraser Plateau, Chilcotin Ranges, Pacific and Cascade Range, Lower Mainland, Okanagan Range, Thompson-Okanagan Plateaus, Columbia Mountains and Highlands, and Southern Rocky Mountains (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Common Pika, see Table 2. The Common Pika is considered by Meidinger and Pojar (1991) to be a "representative species" in the Coastal Western Hemlock, Mountain Hemlock, Interior Douglas-fir, Interior Cedar-Hemlock, Montane Spruce, Engelmann Spruce-Subalpine Fir, and Alpine Tundra biogeoclimatic zones.

Status

O. p. septentrionalis is on the 1998 provincial red-list of candidate taxa for threatened or endangered status. All other subspecies are probably not in jeopardy and are on the provincial Yellow list.

Habitat requirements

Pikas are obligate residents of broken rock talus habitat (Broadbooks 1965) that is adjacent to a suitable food source (see "Food habits" below) (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988; Smith and Weston 1990). Because pikas can not tolerate the high diurnal temperatures typically associated with lower elevations, they are often considered to be a high-elevation species (up to 3,000-m) (Smith and Weston 1990). However, pikas can be found near sea level as well as within mountainous regions.

Food habits

Pikas are generalized herbivores, and as such, will eat most of the herbaceous plants found adjacent to the talus slope where they reside (Smith and Weston 1990). Their diets, although varying with the vegetation's phenological stage of development, typically consist of grasses, sedges, tender flowering plants, and young shoots of dwarf shrubs (Banfield 1974; Stevens and Lofts 1988). The most common plants found eaten are short alpine grasses (Huntley *et al.* 1986). Like all lagomorphs, pikas are also caprophagic (ingests its own feces) (Smith and Weston 1990). Because pikas do not hibernate (Krear 1965 as cited in Smith and Weston 1990), they almost exclusively rely on dried vegetation that has been stored during the previous summer months (Banfield 1974; Smith and Weston 1990). These food caches are often referred to as hay piles and are usually found under the protection of large boulders within their territory (Cowan and Guiguet 1973; Banfield 1974; Smith and Weston 1990). During the winter, pikas will also feed on adjacent meadow vegetation via snow tunnels and on lichens (Conner 1983; Smith and Weston 1990).

Daily activity and movement patterns

In general, pikas are diurnal in activity, rising early in the morning and retiring soon after sunset (Banfield 1974). However, because pikas do not tolerate high temperatures, they are only active about 30% of the daylight hours and have been observed shunning activity throughout the mid-day hours of warm days. This bimodal activity pattern becomes more evident with decreasing elevation (Smith 1974). When visibly active, a pika's behavior can be divided into four main types. From most, to least common they are: surveillance (may account for 50% of activity), haying or feeding, vocalizing, and territory establishment and/or maintenance (Smith and Weston 1990).

Seasonal activities and movement patterns

Because the pika does not hibernate it is active throughout the year (Krear 1965 as cited in Smith and Weston 1990). Movement does not vary significantly with seasons, as the pika is restricted to its talus slope and nearby meadow habitat all year round (Cowan and Guiguet 1973; Banfield 1974). Pikas first breed as yearlings and have two litters per year as adults (Smith and Ivins 1983). The first litter of the year is conceived approximately one month before snow melt so that the flush of young spring growth is available for the lactating females upon parturition after the one month gestation period (Severald 1950; Millar 1972). The second litter can be born as late as September (Banfield 1974), but is usually conceived immediately after the birth of the first litter (Millar 1972). The average litter-size for pikas is three (Millar 1973; Banfield 1974), but ranges from two to six (MacDonald and Jones 1987).

Other

Pikas are often very vocal and can be heard for quite some distance. Their vocalizations have been described as a "shrill nasal bleat" and a "chattered series of barks" (Broadbooks 1965; Cowan and Guiguet 1973; Banfield 1974).

2.2 Collared Pika, *Ochotona collaris* (Nelson)

Synonyms

Ochotona princeps collaris, *Lagomys collaris* (MacDonald and Jones 1987; Nagorsen 1990), or *Ochotona alpina complex* (Weston 1982).

Other common names

Rock rabbit (Cowan and Guiguet 1973), cony or rock cony, whistling hare, piping hare, mouse hare (MacDonald and Jones 1987) or hay-maker (Smith and Weston 1990).

Distribution within British Columbia

The Collared Pika can be found only in the subarctic mountain ranges of the extreme northwestern tip of the province (Cowan and Guiguet 1973; Banfield 1974; MacDonald and Jones 1987).

Ecoregions: Tatshenshini, Northern Mountains and Plateaus, and Boundary Ranges (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Collared Pika, see Table 2. The Collared Pika is not considered, by Meidinger and Pojar (1991) to be a "representative species" in any of the 14 biogeoclimatic zones.

Status

The Collared Pika is on the provincial Yellow list.

Habitat requirements

The Collared Pika, like the Common Pika, is an obligate resident of broken talus habitat, bordered by an appropriate food source (Cowan and Guiguet 1973; Banfield 1974; MacDonald and Jones 1987; Stevens and Lofts 1988). For more details, see "Common Pika (2.1) - Habitat requirements".

Food habits

The Collared Pika, like the Common Pika (*O. princeps*), is a generalized herbivore that stockpiles food (hay piles) for consumption during the winter (Cowan and Guiguet 1973; Banfield 1974; MacDonald and Jones 1987; Stevens and Lofts 1988). For more details, see "Common Pika (2.1) - Food habits".

Daily activity and movement patterns

Like the Common Pika (*O. princeps*), the Collared Pika is diurnal, with most of its activity occurring in the morning and late afternoon (Banfield 1974; MacDonald and Jones 1987). Movement patterns are generally restricted to the safety of the talus slopes and nearby meadow (Cowan and Guiguet 1973; Broadbooks 1965; MacDonald and Jones 1987). The movements and activities of pikas are often concerned with surveillance, feeding and/or haying, vocalizing, and territory maintenance or establishment (Smith and Weston 1990). For more details, see "Common Pika (2.1) - Daily activity and movement patterns".

Seasonal activities and movement patterns

The Collared Pika does not hibernate, rather it is active year-round (MacDonald and Jones 1987). As with daily activities and movements, seasonal activity and movements are restricted to the talus slope and nearby vegetation (Cowan and Guiguet 1973; Banfield 1974). The peak breeding season for the Collared Pika is between May and early June, when litters of two to six young are conceived (MacDonald and Jones 1987). Like the Common Pika (*O. princeps*), the Collared Pika has a gestation period of 30 days (Severald 1950; MacDonald and Jones 1987). For more details, see "Common Pika (2.1) - Seasonal activity and movement patterns".

Other

The Collared Pika differs only slightly from the only other species of pika found in North America, the Common Pika (*O. princeps*), and requires cranial analysis to discern the two species from each other (MacDonald and Jones 1987; Smith and Weston 1990). In fact, some authors do not recognize the Collared Pika as a species, referring to it as a subspecies of Common Pika, called *Ochotona princeps collaris* (Banfield 1974). However, identification of the two pikas is made easy and accurate by the fact that the Collared Pika and Common Pika are separated by an 800-km gap, where no pikas are found (Cowan and Guiguet, 1973; MacDonald and Jones 1987; Smith and Weston 1990).

2.3 Columbian Ground Squirrel, *Spermophilus columbianus* (Ord)

Synonyms

Anisonyx brachiura (Elliot and Flinders 1991), *Arctomys columbianus, A. parryi var. erithrogluteia*, *Citellus columbianus*, or *Spermophilus empetra var. erythroglutaeus* (Nagorsen 1990).

Other common names

Mountain gopher (Woods 1980).

Distribution within British Columbia

The Columbian Ground Squirrel can be found within southeastern and south-central parts of the province (Stevens and Lofts 1988). More specifically, it inhabits the Rocky Mountains (north, to the headwaters of the Smokey River), the Selkirks, Monashee Range, and the mountains west of the North Thompson River (Cowan and Guiguet 1973). Their distribution is also noted as being disjunct within the valleys between the mentioned mountain ranges (Cowan and Guiguet 1973).

Ecoregions: Alberta Plateau, Central Rocky Mountains, Southern Rocky Mountains, Southern Rocky Mountain Trench, Columbia Mountains and Highlands, Fraser Basin, Fraser Plateau, Thompson-Okanagan Plateaus, Okanagan Range, and Pacific and Cascade Ranges (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Columbian Ground Squirrel, see Table 2. The Columbian Ground Squirrel is considered by Meidinger and Pojar (1991) to be a "representative species" in the Interior Douglas-fir, Interior Cedar-Hemlock, Engelmann Spruce-Subalpine Fir, and Alpine Tundra biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Columbian Ground Squirrel is not protected as it is probably not in jeopardy (Stevens and Lofts 1988). It is on the provincial Yellow list.

Habitat requirements

The Columbian Ground Squirrel is usually found within open areas (Banfield 1974; Stevens and Lofts 1988). Cowan and Guiguet (1973) state that its habitat is extremely varied across the province, ranging from alpine meadows to arid grasslands, and rarely in heavy timber (Elliot and Flinders 1991). The burrowing habits of this ground squirrel requires that their habitat be located on well drained, friable soils (Stevens and Lofts 1988; Elliot and Flinders 1991). Ramirez and Hornocker (1981) noted that the Columbian Ground Squirrel will readily use modified habitats such as clearcuts.

Food habits

The Columbian Ground Squirrel is primarily a herbivore, however, it will make a meal of ground-nesting birds, mice, dead fish, and insects (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988). A wide variety of plant parts including flowers, leaves, seed, bulbs, and fruits are consumed by this squirrel (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988; Elliot and Flinders 1991). Food is not usually cached, however, old males have been observed stockpiling a small amount of seed and/or bulbs in their hibernacula (Shaw 1926 as cited in Elliot and Flinders 1991). These caches are then consumed when the squirrel emerges from hibernation in early spring, when food sources are often still scarce (Elliot and Flinders 1991).

Daily activity and movement patterns

The Columbian Ground Squirrel is strictly diurnal, rising 10 minutes before sunrise and retiring 20 minutes after sunset (Banfield 1974; Elliot and Flinders 1991). A network of tunnels (up to 20 m in length with an average of 11 entrances) provide the squirrel with thermal cover in the winter and escape cover during the active summer months (Cowan and Guiguet 1973; Banfield 1974; Elliot and Flinders 1991). Time spent away from the safety of their escape tunnels (usually foraging) is minimized in order to decrease the probability of predation (Andrusiak and Harestad 1989). This squirrel rarely walks, rather scurries from place to place (Banfield 1974). A frequent activity of this colonial ground squirrel is a greeting behaviour, often referred to as "kissing" (Stiener 1975 as cited in Elliot and Flinders 1991). Such "kissing" is actually the simultaneous sniffing of each other’s oral glands, facilitated by the slight tilting of the two squirrel’s heads (Elliot and Flinders 1991). The Columbian Ground Squirrel is very vocal with a vocabulary of seven different types of vocalizations (Harris *et al*. 1983 as cited in Elliot and Flinders 1991). Most of these vocalizations, commonly described as a metallic chirp, and are usually expressed in response to a perceived threat (Banfield 1974; Elliot and Flinders 1991).

Seasonal activities and movement patterns

Columbian Ground Squirrels are only active for approximately 30% of the year (Dobson and Murie 1987), spending the remaining 70% in a deep torpor within a hibernaculum located up to 2-m underground (Banfield 1974). It is difficult to provide specific dates for the timing of hibernation, emergence, and breeding seasons, as these activities vary with latitude, altitude, slope, and aspect (Murie and Harris 1984). Generally, the timing of these events is delayed with increasing latitude and altitude (Michener 1977; Murie and Harris 1984). Hibernation can begin as early as mid-July or as late as mid-August (Cowan and Guiguet 1973). Emergence dates can vary from early March to early May (Cowan and Guiguet 1973). Adult males emerge first from hibernation, about 10 days before the females (Cowan and Guiguet 1973; Banfield 1974; Murie and Harris 1984 as cited in Elliot and Flinders 1991). Breeding commences soon after the females have emerged (Elliot and Flinders 1991). After a gestation period of 24 days (Cowan and Guiguet 1973; Michener 1977) the squirrel gives birth to an average litter size of three, the only litter of the year (Murie and Dobson 1987 as cited in Elliot and Flinders 1991).

Other

Although this squirrel’s tunnel network may contain as many as 35 entrance holes, only one, the main entrance, is easily seen. The other entrances serve as safety-escapes, or plunge-holes, and are much less conspicuous (Banfield 1974; Elliot and Flinders 1991).

2.4 Arctic Ground Squirrel, *Spermophilus parryii* (Richardson)

Synonyms

Citellus parryii (Cowan and Guiguet 1973), *C. plesius, C. undulatus*, *Spermophilus empetra plesius*, or *S. undulatus* (Nagorsen 1990).

Other common names

Parry ground squirrel (Cowan and Guiguet 1973; Nagorsen 1990), parka squirrel (Whitaker 1988), sik-sik, or sulsik (Banfield 1974).

Distribution within British Columbia

The Arctic Ground Squirrel is found in the northeastern corner of the province. More specifically, this ground squirrel can be found from the southern tributaries of the Stikine River and headwaters of the Klappan and Spatsizi Rivers, north into the Yukon, west into Alaska, and east into the north central regions of the province (Cowan and Guiguet 1973).

Ecoregions: Tatshenshini, Boundary Ranges, Skeena and Omineca Mountains, Northern Mountains and Plateaus, and Liard Basin (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Arctic Ground Squirrel, see Table 2. The Arctic Ground squirrel is considered by Meidinger and Pojar (1991) to be a "representative species" in the Spruce-Willow-Birch and Alpine Tundra biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Arctic Ground Squirrel is on the provincial Yellow list.

Habitat requirements

The Arctic Ground Squirrel is found within tundra regions beyond the treeline and within openings of northern forests (Banfield 1974). Because of the northern extent of the arctic ground squirrel's distribution, permafrost is the main limiting factor for suitable habitat (Carl 1971; Banfield 1974; Whitaker 1988). Permafrost restricts these squirrels, as they are unable to dig their burrows in frost-hardened soils (Carl 1971; Banfield 1974). Because increased soil moisture decreases the depth to permafrost, arctic ground squirrels prefer well drained soils such as glacier deposited eskers, and moraines (Banfield 1974). Where depth to permafrost is limiting for burrow excavation, burrows may be largely located within the organic layer, rather than within the mineral soil (Banfield 1974).

Food habits

Arctic ground squirrels are primarily herbivorous, however, like other ground squirrels, they will occasionally feed on the meat of dead lemmings, birds, and caribou (Banfield 1974). This squirrel consumes most parts of the grasses, forbs, and woody plants found within their home range (Banfield 1974). The sparse and patchy nature of the tundra vegetation necessitates a large home range (relative to the southern ground squirrels) in order for the arctic ground squirrel to meet its dietary demands (Carl 1971). In late summer, this squirrel caches an average of 1.8 kg (4 lb.) of willow leaves, grass seed heads, and bog rush capsules for consumption upon emergence from hibernation (Banfield 1974).

Daily activity and movement patterns

Arctic Ground Squirrels, like other ground squirrels, are diurnal (active from approximately 4:00 AM to 9:30 PM), even though they live most of their active season within 24-hour daylight (Banfield 1974). It is believed that these squirrels respond to light intensity cues as other squirrels do to day and night cues. Some authors, such as Banfield (1974), do not consider this squirrel to be territorial while others, such as Carl (1971), state that a significant portion of its active days is spent defending its territory. Foraging is concentrated near the safety of the burrows, however, the sparse nature of the tundra food source requires that this squirrel travel further away from the burrows than southern ground squirrels do for feeding (Banfield 1974). Like other ground squirrels, the Arctic Ground Squirrel is often observed sprawled out on its belly on a dirt mound, soaking up the warm sun (Banfield 1974; Whitaker 1988). Conversely, during adverse weather, activity is largely confined to their burrows (Banfield 1974; Whitaker 1988).

Seasonal activities and movement patterns

Arctic Ground Squirrels have a longer active season than the Columbian Ground Squirrels, but are still dormant for about seven months of the year (Cowan and Guiguet 1973; Banfield 1974). Dormancy typically begins in September with the adults entering hibernation slightly before the yearlings, as it generally takes a yearling longer to accumulate sufficient fat reserves to last them through the long period of torpor (Carl 1971; Banfield 1974). Emergence is related to latitude and altitude (becoming later with increasing latitude and/or altitude), but can be generalized as mid to late April (Cowan and Guiguet 1973; Michener 1984). Breeding occurs as soon as the females emerge from hibernation (Carl 1971; Woods 1980). After a gestation period of 25 days, the Arctic Ground Squirrel gives birth to her only litter of the year (Banfield 1974). Little is known about the litter sizes of this squirrel, however, Carl (1971) observed an average of 5.5 to 6.1 young per female.

Other

The Arctic Ground Squirrel is the largest ground squirrel in North America and is easily distinguished from its closest relative, the Columbian Ground Squirrel (*Spermophilus columbianus*), by its northern geographic distribution(Cowan and Guiguet 1973; Banfield 1974; Elliot and Flinders 1991).

2.5 Golden-mantled Ground Squirrel, *Spermophilus lateralis* (Say)

Synonyms

Citellus lateralis tescorum (Cowan and Guiguet 1973), *Callospermophilus lateralis* (Nagorsen 1990), *C. trepidus*, *C. bernardinus, Spermophilus bernardinus*, *Tamias wormani*, *T. cinerascens*, T. *chrysodeirus*, or *Sciurus lateralis* (Bartels and Thompson 1993).

Other common names

Mantled ground squirrel (Cowan and Guiguet 1973; Nagorsen 1990), copper head (Whitaker 1988), the big chipmunk (Banfield 1974), rock squirrel, callo (Bartels and Thompson 1993), golden chipmunk, yellow head, or Say’s chipmunk (Woods 1980).

Distribution within British Columbia

The Golden-mantled Ground Squirrel has a distribution similar to that of the Columbian Ground Squirrel (*S. columbianus*); the southeastern and south-central parts of the province. More specifically, this squirrel can be found from the 49th parallel north to Mount Selwyn, and west to the east side of the Okanagan Valley (Cowan and Guiguet 1973).

Ecoregions: Central Rocky Mountains, Southern Rocky Mountains, Southern Rocky Mountain Trench, Columbia Mountains and Highlands (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Golden-mantled Ground Squirrel, see Table 2. The Golden-mantled Ground Squirrel is considered by Meidinger and Pojar (1991) to be a "representative species" in the Bunchgrass, Ponderosa Pine, Interior Douglas-fir, Interior Cedar-Hemlock, Montane Spruce, Engelmann Spruce-Subalpine Fir, and Alpine Tundra biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Golden-mantled Ground Squirrel is on the provincial Yellow list.

Habitat requirements

Cowan and Guiguet (1973) report that the Golden-mantled Ground Squirrel occupies a wide variety of habitats; ranging from rock slides above the timberline down to rocky areas in valley bottoms and semi-arid areas. This squirrel has also been reported to inhabit recently logged and/or burnt forests, provided that there is sufficient amounts of woody debris remaining to serve as shelter (McKeever 1964; Cowan and Guiguet 1973; Banfield 1974).

Food habits

The Golden-mantled Ground Squirrel is an omnivore (Bartels and Thompson 1993). This squirrel will consume hypogeous, or underground fungi detected by smell and recovered by digging, flowers and fruits of a variety of plants including large quantities of conifer seeds, insects, eggs and young birds, voles, lizards, and carrion of all types (McKeever 1964; Cowan and Guiguet 1973; Banfield 1974; Bartels and Thompson 1993). Of these food types, hypogeous fungi is considered by Banfield (1974) to be the most important, comprising from 65 to 90% (by volume) of the squirrel’s stomach contents. The Golden-mantled Ground Squirrel stockpiles large quantities of food plants underground for consumption upon emergence from hibernation (Bartels and Thompson 1993).

Daily activity and movement patterns

The Golden-mantled Ground Squirrel, like other ground squirrels, is typically diurnal, active from sunup to sundown, but may remain within the shelter of their burrows during the hottest times of the day and during rainy, windy and/or cold days (Banfield 1974; Bartels and Thompson 1993). Activities and movements, daily and seasonal, are both concentrated near the safety of their tunnels, however, foraging opportunities (*e.g.,* handouts from a nearby campground) may lure this squirrel up to 300-m from its nearest tunnel (Banfield 1974). Like many ground squirrels, the Golden-mantled Ground Squirrel spends a considerable portion of sunny days stretched out on its belly on a mound of dirt or a rock, sunbathing (Banfield 1974; Bartels and Thompson 1993).

Seasonal activities and movement patterns

Golden-mantled Ground Squirrels are only active for approximately four months of the year, spending the remaining eight months in a deep state of torpor within an underground hibernaculum (Cowan and Guiguet 1973; Banfield 1974). Dates for entrance into, and emergence from hibernation, vary with latitude, altitude, slope, and aspect, but can be generalized as late August and late April, respectively (Cowan and Guiguet 1973; Phillips 1984; Bartels and Thompson 1993). Breeding commences soon after the females emerge from hibernation. Following a gestation period of 26 to 33 days, an average litter size of four to six is born in May (Cowan and Guiguet 1973; Banfield 1974; Phillips 1984; Bartels and Thompson 1993). Only one litter is born each year.

Other

The Golden-mantled Ground Squirrel is an atypically silent ground squirrel, only occasionally vocalizing (described as a high pitched chirp or squeal) when threatened (Banfield 1974; Whitaker 1988; Bartels and Thompson 1993). This ground squirrel is also unique in that it does not leave any conspicuous traces of its burrowing activity (Woods 1980). Although mainly terrestrial, this squirrel will swim across narrow creeks and even climb small trees (Banfield 1974; Bartels and Thompson 1993).

2.6 Cascade Mantled Ground Squirrel, *Spermophilus saturatus* (Rhoads)

Synonyms

Cittelus saturatus (Cowan and Guiguet 1973), *Callospermophilus lateralis saturatus*, *Tamias lateralis saturatus* (Nagorsen 1990), or *Spermophilus lateralis saturatus* (Banfield 1974).

Other common names

Golden-mantled ground squirrel (Banfield 1974; Woods 1980), Cascade mantled ground squirrel (Cowan and Guiguet 1973; Nagorsen 1990), copper head (Whitaker 1988), the big chipmunk (Banfield 1974), rock squirrel, callo (Bartels and Thompson 1993), golden chipmunk, or yellow head (Woods 1980).

Distribution within British Columbia

The Cascade Mantled Ground Squirrel has a fairly limited distribution; the extreme southern part of the province. More specifically, this rodent is confined to an area east of the Fraser River; south of the Nicola River system; and west of the Okanagan system (Leung 1991).

Ecoregions: Okanagan Range, Thompson-Okanagan Plateaus, and Pacific and Cascade Ranges (adapted from Leung 1991; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Cascade Mantled Ground Squirrel, see Table 2. The Cascade Mantled Ground Squirrel is not considered by Meidinger and Pojar (1991) to be a "representative species" in any of the biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Cascade Mantled Ground Squirrel is on the 1998 provincial blue list of taxa which are vulnerable or sensitive.

Habitat requirements

Same as for the Golden-mantled Ground Squirrel (*S. lateralis*). See "Golden-mantled Ground Squirrel (2.5) - Habitat requirements".

Food habits

Same as for the Golden-mantled Ground Squirrel (*S. lateralis*). See "Golden-mantled Ground Squirrel (2.5) - Food habits".

Daily activity and movement patterns

Same as for the Golden-mantled Ground Squirrel (*S. lateralis*). See "Golden-mantled Ground Squirrel (2.5) - Daily activity and movement patterns".

Seasonal activities and movement patterns

Same as for the Golden-mantled Ground Squirrel (*S. lateralis*). See "Golden-mantled Ground Squirrel (2.5) - Seasonal activity and movement patterns".

Other

Although very similar, *S. saturatus* and *S. lateralis* are separate species (Cowan and Guiguet 1973; Stevens and Lofts 1988; Bartels and Thompson 1993). However, many authors disagree with this classification and identify the Cascade Mantled Ground Squirrel as a subspecies of the Golden-mantled Ground Squirrel (*S. lateralis saturatus*), and refer to them collectively as the mantled ground squirrels (Banfield 1974; Woods 1980).

2.7 Yellow-bellied Marmot, *Marmota flaviventris* (Audubon and Backman)

Synonyms

Arctomys flaviventris, *A. flaviventer avarus*, *A. dacota*, *Marmota flaviventer*, *M. flaviventer avarus*, or *M. engelhardti* (Frase and Hoffman 1980; Nagorsen 1990).

Other common names

Yellow-footed marmot, rockchuck, mountain marmot (Whitaker 1980), yellow belly, yellow groundhog, or yellow whistler (Woods 1980).

Distribution within British Columbia

The Yellow-bellied Marmot is found within the southern interior part of the province. More specifically, this marmot can be found from Hope to Trail, including the Okanagan, Nicola Valley, and southern Cariboo (Cowan and Guiguet 1973; Stevens and Lofts 1988).

Ecoregions: Columbia Mountains, Fraser Plateau, Chilcotin Ranges, Pacific and Cascade Ranges, Thompson-Okanagan Plateaus, and Okanagan Range (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Yellow-bellied Marmot see Table 2. The Yellow-bellied Marmot is considered, by Meidinger and Pojar (1991) to be a "representative species" in the Bunchgrass, Ponderosa Pine, Interior Douglas-fir, and Interior Cedar-Hemlock biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Yellow-bellied Marmot is not protected, as it is probably not in jeopardy (Stevens and Lofts 1988). It is on the provincial Yellow list.

Habitat requirements

The Yellow-bellied Marmot occupies dry areas of the province, and is found at highest densities where there is an abundance of broken rock to facilitate their semi-fossorial, burrowing habits, as well as providing them with a good vantage point for surveillance and a place for sunbathing (Cowan and Guiguet 1973; Banfield 1974; Frase and Hoffman 1980; Stevens and Lofts 1988). These marmots will also venture into ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) forests, provided that there is sufficient rocky habitat to facilitate their burrowing (Cowan and Guiguet 1973; Banfield 1974). Anderson *et al.* (1976*a*) reports that good burrowing habitat, and thus suitable denning sites, as the main limiting factor for the distribution of this marmot.

Food habits

The Yellow-bellied Marmot is a herbivore that will consume a variety of plants including graminoids, forbs (especially dandelions (*Taraxicum* sp.) and clovers (*Trifolium* sp.), seeds, and roots (Frase and Hoffman 1980; Stevens and Lofts 1988). Feeding is generally concentrated near the safety of the marmot's burrows (Frase and Hoffman 1980).

Daily activity and movement patterns

The Yellow-bellied Marmot is typically bimodal in activity, with peaks in the early morning and late afternoon, while they escape the heat of mid-day in the buffered conditions of their burrows (Frase and Hoffman 1980; Barash 1989). However, a unimodal activity peak at mid-day has been observed during early spring, late summer, and in times of inclement weather (Barash 1989). The reason for this unimodal activity is the same in all cases; to make best use of what solar heat is available during these cooler days. The Yellow-bellied Marmot spends most of its above-ground activity feeding, sunbathing, and watching for predators (Frase and Hoffman 1980). For safety, movement of marmots is generally restricted to the vicinity of their burrows (Frase and Hoffman 1980).

Seasonal activities and movement patterns

The Yellow-bellied Marmot is only active for about four months of the year (from April to August) and spends the remaining eight months in a deep torpor within an underground hibernaculum (Cowan and Guiguet 1973; Svendsen 1976; Frase and Hoffman 1980). Copulation occurs soon after the marmots emerge from hibernation (Nee 1969). An average litter of four or five young are born after a 30 day gestation period in early May (Nee 1969; Cowan and Guiguet 1973; Frase and Hoffman 1980). Marmots do not move significant distances from the safety of their burrows during any time of the year.

Other

Wildlife managers should take care when handling this marmot, as it is a favoured host of the *Dermacentor andersoni* tick; the transmitter of Rocky Mountain spotted fever, which may cause paralysis if contracted by humans (Cowan and Guiguet 1973; Woods 1980).

2.8 Woodchuck, *Marmota monax* (Linnaeus)

Synonyms

Arctomys monax or *Marmota ochracea* (Nagorsen 1990).

Other common names

Groundhog, (Nagorsen 1990), marmot (Whitaker 1980), or whistle pig (Woods 1980).

Distribution within British Columbia

The Woodchuck has a disjunct distribution that is most easily described in terms of the three subspecies found within the province. *Marmota monax canadensis* is found within the Peace River District and East into Alberta, *M. m. ochracea* in the northwestern (Haines Triangle to Atlin) and north-central (Liard River) parts of the province, and *M. m. petrensis* from the Stikine River south to the Chilcotin River, and through the mountains east of the Fraser River to Revelstoke and Creston (Cowan and Guiguet 1973; Nagorsen 1990).

Ecoregions: Boundary Ranges, Tatshenshini Basin, Northern Mountains and Plateaus, Liard Basin, Northern Rocky Mountains, Alberta Plateau, Fort Nelson Lowland, Central Rocky Mountains, Columbia Mountains and Highlands, Fraser Basin, Skeena and Omineca Mountains, Fraser Plateau, Nass Basin, and Nass Ranges (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Woodchuck, see Table 2. The Woodchuck is not considered, by Meidinger and Pojar (1991) to be a "representative species" in any of the biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Woodchuck is on the provincial Yellow list.

Habitat requirements

The Woodchuck, like other marmots, excavates burrows for denning and nesting, and as such, prefers well drained soils, preferably on a slope, to reduce the risks of flooding (Banfield 1974; Woods 1980). The Woodchuck will make a home in alpine rock slides, but is more frequently found in open parkland or field-edge habitats (Cowan and Guiguet 1973). Woods (1980) states that woodchucks often use two different habitats during the course of the year, locating their burrows within pasture or field-type habitat during the active season because of high forage potential and then relocating to the sheltered habitat of a forest edge for preferred burrowing sites under the protective roots of trees for hibernation.

Food habits

Woodchucks are primarily grazers of green plants and consume many of the herbs and grasses found within their range (Cowan and Guiguet 1973; Banfield 1974). Woods (1980) noted dandelion (*Taraxicum* sp.), clover (*Trifolium* sp.), and alfalfa (*Medicago* sp.) to be this marmot’s favourite plants. Woodchucks will also make an occasional meal of ground-nesting birds and large insects (Banfield 1974). During early spring, before the flush of new growth, this marmot has been observed feeding on the bark and twigs of trees (Banfield 1974; Woods 1980).

Daily activity and movement patterns

The Woodchuck, like other marmots, is bimodal in activity and will change to unimodal activity during cooler parts of the active season or during inclement weather (see Yellow-bellied Marmot (2.7) - Daily activity and movement patterns" for more detail) (Barash 1989). Although woodchucks will venture considerable distances from the safety of their burrows to forage, they can usually be found close to their burrows (Banfield 1974).

Seasonal activities and movement patterns

Woods (1980) noted that woodchucks enter hibernation in September and October and emerge from hibernation during March. As with all hibernating squirrels, there is considerable variation in the timing of these events as they are influenced by latitude, altitude, slope, and aspect of the woodchuck’s habitat

(Barash 1989). An average of four young per litter are born in May (only litter of the year) after a gestation period of 31 to 32 days (Cowan and Guiguet 1973; Banfield 1974; Woods 1980).

Other

The woodchuck, although capable of a variety of vocalizations, is atypically silent for this genus (Cowan and Guiguet 1973). This marmot is also unique in that it only rarely shares a den with a conspecific, and has received its specific name of "*monax*" (monax is a Latin word meaning "solitary") because of its predominantly solitary nature (Banfield 1974; Woods 1980).

2.9 Hoary Marmot, *Marmota caligata* (Eschscholtz)

Synonyms

Arctomys caligatus, *A. okanaganus*, *Marmota okanagana*, *M. oxytona*, or *M. sibila* (Nagorsen 1990).

Other common names

Whistler (Nagorsen 1990), white whistler, whistler of the rocks (Woods 1980), rockchuck, or mountain marmot (Whitaker 1988).

Distribution within British Columbia

The Hoary Marmot has the most extensive range of the four marmots found in this province (Cowan and Guiguet 1973). Stevens and Lofts (1988) sum up this marmot’s distribution as the mountainous areas of the mainland at high elevations.

Ecoregions: All except four of the mainland ecoregions. The hoary marmot does not appear to be found within the Fort Nelson Lowland, Nass Ranges, Okanagan Range, and Thompson-Okanagan Plateaus (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the hoary marmot, see Table 2. The hoary marmot is considered, by Meidinger and Pojar (1991) to be a "representative species" in the Engelmann Spruce-Subalpine Fir and Alpine Tundra biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Hoary Marmot is not protected, as it is probably not in jeopardy (Stevens and Lofts 1988). It is on the provincial Yellow list.

Habitat requirements

The Hoary Marmot is essentially a high elevation species that prefers boulder-filled, alpine meadow habitats (Cowan and Guiguet 1973; Banfield 1974; Woods 1980; Stevens and Lofts 1988). This marmot will occupy lower elevations where there is a sufficient amount of rocky habitat, as provided by rock-slides (Cowan and Guiguet 1973). This rocky habitat is required to facilitate a well structured tunnel network which is used for thermal cover from temperature extremes, and escape cover from predators, such as the Grizzly Bear (*Ursus arctos*) that would otherwise dig them up, and to provide a good post for sunbathing and alarm calling (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988).

Food habits

The Hoary Marmot is a generalized herbivore that will consume most of the herbs and forbs found near its den (Cowan and Guiguet 1973; Banfield 1974). Woods (1980) states that its large appetite is the Achilles heel of this marmot, as distant foraging pastures will often lead the hoary marmot 200 to 300 m away from the safety of its burrows.

Daily activity and movement patterns

The Hoary Marmot, like other marmots, is bimodal in activity and will change to unimodal activity during cooler parts of the active season or during inclement weather (for more detail, see Yellow-bellied Marmot (2.7) - Daily activity and movement patterns") (Barash 1989). This colonial marmot is especially tolerant of its conspecifics, and spends considerable time each day socializing, as well as feeding and sunning (Banfield 1974; Woods 1980). As mentioned above, the Hoary Marmot will venture considerable distances from its den in search of good foraging opportunities (Woods 1980).

Seasonal activities and movement patterns

The Hoary Marmot is typical of all marmots in that it spends most of the year (eight months) in hibernation. This marmot is generally only active from April to late August. It mates soon after emergence in April or May, gives birth to an average litter size of four or five after a 29 day gestation period, and then accumulates enough fat reserves to fuel its metabolism for another eight months of hibernation (Cowan and Guiguet 1973; Banfield 1974; Woods 1980; Stevens and Lofts 1988).

Other

Banfield (1974) states that the Hoary Marmot is the largest of all North American marmots, weighting up to 13.6 kg (30 lbs). Although all marmots are capable of vocalizations, this marmot is known as the champion whistler, as is evident by its array of common names. Its vocalizations have been described as a long shrill whistle, like that of a familiar police whistle (Banfield 1974).

2.10 Vancouver Island Marmot, *Marmota vancouverensis* Swarth

Synonyms

None (Nagorsen 1990).

Other common names

Vancouver Marmot (Nagorsen 1990) or little brown pig (Woods 1980).

Distribution within British Columbia

The Vancouver Island marmot is confined to the mountains of central and south Vancouver Island). More specifically, this marmot has been found from Jordan River north to the Forbidden Plateau (Cowan and Guiguet 1973; Nagorsen 1987), however, Munro *et al*. (1985) report that their distribution has increased since the 1970's.

Ecoregions: Western Vancouver Island and Eastern Vancouver Island (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Vancouver Island Marmot, see Table 2. The Vancouver Island Marmot is not considered, by Meidinger and Pojar

(1991) to be a "representative species" in any of the biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Vancouver Island Marmot is the rarest of all North American marmots, and as such, was officially designated an endangered species by Order in Council of the Province of British Columbia in March of 1980 (Munro *et al.* 1985). It is on the 1998 provincial red list.

Habitat requirements

The Vancouver Island Marmot prefers alpine or subalpine meadow habitat from 975 to 1430-m (Cowan and Guiguet 1973; Munro *et al*. 1985). Nagorsen (1987) also noted that this marmot prefers steep south facing slopes where snow creep and avalanches inhibit the establishment of trees, which in return, promotes forage rich, meadow habitat. The artificially created treeless environment of ski slopes has also been used by the Vancouver Island Marmot (Munro *et al*. 1985; Ministry of Environment 1991).

Food habits

The Vancouver Island Marmot is a herbivore that will eat many of the plants found within the alpine or subalpine habitat it inhabits (Nagorsen 1987). Milko (1984) noted that graminoids are the most important food source in early spring, whereas, forbs make up the majority of their diet in summer (as cited in Nagorsen 1987).

Daily activity and movement patterns

The Vancouver Island Marmot, like other marmots, is bimodal in activity and will change to unimodal activity during cooler parts of the active season or during inclement weather (Nagorsen 1987) (for more detail, see Yellow-bellied Marmot (2.7) - Daily activity and movement patterns") (Barash 1989). This marmot spends the majority of each active day foraging and resting near its burrows (Nagorsen 1987).

Seasonal activities and movement patterns

The Vancouver Island Marmot spends the majority of each year (seven to eight months) in hibernation from early October to early May (Nagorsen 1987). Rates of behavioural patterns, including greeting and play-fighting, are highest during June, and decline from July up until hibernation (Nagorsen 1987).

Other

The Vancouver Island Marmot is the only mammalian species endemic to Canada that has been classified as an endangered species (Nagorsen 1987). This endangered status requires that extra care be taken not to disrupt or harm this species in any way during investigations of its abundance.

2.11 Yellow-pine Chipmunk, *Tamias amoenus* Allen

Synonyms

Eutamias amoenus (Cowan and Guiguet 1973), *E. ludibundus, E. canicaudus, E. caurinus* (Sutton 1992), *Tamias quadrivittatus felix* or *T. quadrivittatus luteiventris* (Nagorsen 1990).

Other common names

Northwestern chipmunk (Cowan and Guiguet 1973; Woods 1980; Nagorsen 1990).

Distribution within British Columbia

The Yellow-pine Chipmunk is found in the central and southern parts of the province. More specifically, this chipmunk is distributed from the rocky mountains to the southern coast and north to the Skeena Valley through the central plateau (Cowan and Guiguet 1973; Stevens and Lofts 1988; Nagorsen 1990).

Ecoregions: Southern Rocky Mountains, Southern Rocky Mountain Trench, Columbia Mountains and Highlands, Fraser Basin, Skeena and Omineca Mountains, Nass Basin, Nass Ranges, Coastal Gap, Fraser Plateau, Chilcotin Ranges, Thompson-Okanagan Plateaus, Okanagan Range, Pacific and Cascade Ranges, and Lower Mainland (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Yellow-pine Chipmunk, see Table 2. The Yellow-pine Chipmunk is considered, by Meidinger and Pojar (1991), to be a "representative species" in the Coastal Western Hemlock, Ponderosa Pine, Interior Douglas-fir, Sub-boreal Pine--Spruce, and Sub-boreal Spruce biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Yellow-pine Chipmunk is not protected as it is probably not in jeopardy (Stevens and Lofts 1988). It is on the provincial Yellow list.

Habitat requirements

The Yellow-pine Chipmunk is typically found in an open forest habitat (Cowan and Guiguet 1973; Stevens and Lofts 1988). Broken habitat with shade, perches, and good shrub cover are preferred (Sutton 1992). This chipmunk is generally thought of as a medium elevation species, however, it will inhabit areas up to treeline (Cowan and Guiguet 1973).

Food habits

The Yellow-pine Chipmunk is omnivorous and will consume a variety of food items including seeds, bulbs, tubers, insects, bird eggs, berries, flowers, green foliage, roots, small animals, and buds (Sutton 1992). Chipmunks rely heavily on coniferous seed for their winter caches (Cowan and Guiguet 1973; Stevens and Lofts 1988; Sutton 1992).

Daily activity and movement patterns

The Yellow-pine Chipmunk is typical of all of the chipmunks found in B.C., in that they are diurnal, rising with sunup and disappearing into their nest around sundown (Banfield 1974; Woods 1980; Sutton 1992). Their activity is most intense in the early morning and late afternoon, however, cool and windy weather will cause chipmunks to seek shelter and concentrate their activity during the warmer noon-hours (Sutton 1992). These solitary animals spend much of their active days eating or gathering food and grooming (Banfield 1974; Woods 1980; Sutton 1992). Although chipmunks are ground dwelling squirrels they are skilled tree climbers and have been observed climbing up to 30-m in search of coniferous seed (Woods 1980; Sutton 1992).

Seasonal activities and movement patterns

The Yellow-pine Chipmunk is only active for about seven months of the year; from April to September or October (Cowan and Guiguet 1973; Sutton 1992;). The remainder of the year is spent in an intermittent state of hibernation (Sutton 1992). Unlike true hibernating squirrels, such as the marmots (*Marmota*) and ground squirrels (*Spermophilus*), chipmunks do not put on an extra layer of fat to fuel their metabolism throughout the winter, rather, they store caches of food within their underground winter dens. Chipmunks revive themselves from their state of torpor approximately every two weeks in order to feed and pass wastes (Stebbins and Orich 1977; Sutton 1992). Breeding commences soon after emergence from hibernation, an average litter size of six (the only litter of the year) is borne in May after a gestation period of 28 days (Woods 1980; Sutton 1992).

Other

Where Yellow-pine and Least Chipmunks (*Tamias minimus*) habitat overlap, the Yellow-pine Chipmunk will usually dominate, forcing the Least Chipmunk into higher, less favoured habitat (Sheppard 1969; Sutton 1992).

2.12 Least Chipmunk, *Tamias minimus* Bachman

Synonyms

Eutamias minimus (Cowan and Guiguet 1973), *E. caniceps*, *E. oreocetes* or *Tamias asiaticus borealis* (Nagorsen 1990).

Other common names

Western chipmunk (Nagorsen 1990) or little chipmunk (Woods 1980).

Distribution within British Columbia

The Least Chipmunk occurs mainly in the northern part of the province. There are also three disjunct populations in the southeastern corner of the province. More specifically this chipmunk is found across the northern section of the province; from the Alberta border, west to Atlin, and south to Burns Lake. Isolated populations also occur at Akamina Pass, southeastern parts of the Selkirk Range, and near Banff, Alberta (Cowan and Guiguet 1973).

Ecoregions: Fort Nelson Lowland, Alberta Plateau, Liard Basin, Northern Mountains and Plateaus, Skeena and Omineca Mountains, Fraser Basin, Northern Rocky Mountains, Central Rocky Mountains, Southern Rocky Mountains, and the Columbia Mountains and Highlands (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Least Chipmunk, see Table 2. The least chipmunk is considered, by Meidinger and Pojar (1991) to be a "representative species" in the Boreal White and Black Spruce and Alpine Tundra biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

Both the *selkirki* and *oreoctes* subspecies of the Least Chipmunk are on the 1998 provincial red list of candidates for legal designation as endangered or threatened.

Habitat requirements

Cowan and Guiguet (1973) note that the areas inhabited by this chipmunk are quite variable. In general, they are found at or above the treeline, however, one of the subspecies (*borealis*) has been found at lower elevations. This chipmunk will often inhabit the open or edge habitats created by fire or logging operations, but is rarely found within closed forests (Banfield 1974).

Food habits

Like other chipmunks, the Least Chipmunk is an omnivore (Cowan and Guiguet 1973; Banfield 1974) (see "Yellow-pine Chipmunk (2.11)-- Food habits" for more details). Cowan and Guiguet (1973) report that seeds and berries are the chipmunk's preferred food. This chipmunk also stores considerable amounts of food within its underground den for consumption during the winter (Cowan and Guiguet 1973; Banfield 1974).

Daily activity and movement patterns

Like other chipmunks, the Least Chipmunk is also diurnal in activity (Banfield 1974; Woods 1980) (see "Yellow-pine chipmunk (2.11) - Daily activity and movement patterns" for more detail). Daily activities and movements are generally concerned with the consumption and caching of food (Banfield 1974).

Seasonal activities and movement patterns

The Least Chipmunk spends a majority of each year in a state of intermittent hibernation (see "Yellow-pine Chipmunk (2.11) - Seasonal activities and movement patterns" for more details). This chipmunk is active from late April or May to September (Cowan and Guiguet 1973). Breeding occurs soon after they emerge from hibernation. This chipmunk gives birth in late May or early June with an average litter size of 5. Juveniles emerge from their winter dens in early spring (Banfield 1974; Glennie 1988).

Other

The Least Chipmunk has earned its common and scientific names for being the smallest of all North American chipmunks (Cowan and Guiguet 1973; Woods 1980).

2.13 Townsend's Chipmunk, *Tamias townsendii* Bachman

Synonyms

Eutamias townsendii (Cowan and Guiguet 1973) or *Tamias cooperi* (Nagorsen 1990).

Other common names

Western chipmunk (Woods 1980).

Distribution within British Columbia

The Townsend's Chipmunk is found in the southwestern corner of the province and has been introduced to Esquimalt, Vancouver Island (Banfield 1974). More specifically, this chipmunk can be found from the coast (south of the Fraser River) east to the Hope-Princeton area (Cowan and Guiguet 1973; Banfield 1974)

Ecoregions: Lower Mainland, Pacific and Cascade Ranges, Okanagan Range, Thompson-Okanagan Plateau, and Eastern Vancouver Island, (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Townsend's Chipmunk, see Table 2. The Townsend's Chipmunk is not considered, by Meidinger and Pojar (1991) to be a "representative species" in any of the biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Townsend's Chipmunk is on the provincial Yellow list.

Habitat requirements

The Townsend's Chipmunk prefers the ecotones between the heavily forested areas and clearings, lakes, and abandoned logging roads (Cowan and Guiguet 1973). Because the majority of these dense thickets of coastal forests have been logged, this chipmunk has adapted to living amongst the debris left by logging activities, however, their abundance is considerably less in this habitat than in climax forests that remain (Banfield 1974).

Food habits

The Townsend's Chipmunk is typical of all chipmunks in its omnivorous food habits (Banfield 1974; Woods 1980) (see "Yellow-pine Chipmunk (2.11) - Food habits" for more details). This chipmunk also caches seeds for consumption during the winter months (Banfield 1974).

Daily activity and movement patterns

The Townsend's Chipmunk, like other chipmunks, is primarily diurnal in activity (Banfield 1974) (see "Yellow-pine Chipmunk (2.11) - Daily activity and movement patterns" for more details). This chipmunk is less conspicuous than the related western chipmunk as it is less vocal and often stays within the cover of dense forests or shrub thickets (Banfield 1974). Townsend's Chipmunks have been observed travelling up to one kilometre to reach a good foraging spot where they proceed to stuff their cheek-pouches and promptly return to their den for consumption or caching of their booty (Woods 1980).

Seasonal activities and movement patterns

Because of the mild coastal winters experienced by the Townsend's Chipmunk, it has the shortest period of intermittent hibernation out of all species in its genus (Banfield 1974). In fact, many remain active all year round (Woods 1980). Hibernation occurs during the coldest months of the year; generally from late November to March; however, timing of these events vary depending on local conditions (Banfield 1974). Like other chipmunks, the Townsend's Chipmunk breeds soon after emergence from its winter den, and gives birth to the only litter of the year in June, after a gestation period of about 30 days (Banfield 1974; Gashwiler 1976).

Other

The Townsend's Chipmunk is the largest of all western chipmunks (Banfield 1974).

2.14 Red-tailed Chipmunk, *Tamias ruficaudus* (Howell)

Synonyms

Eutamias ruficaudus (Cowan and Guiguet 1973; Best 1993)

Other common names

Rufous-tailed Chipmunk (Nagorsen 1990).

Distribution within British Columbia

The Red-tailed Chipmunk is found in two disjunct populations in the southeastern corner of the province. More specifically, one population is found in the extreme southern Canadian Rockies, and the other in the southern Kootenays (Cowan and Guiguet 1973; Nagorsen 1990)

Ecoregions: Southern Rocky Mountains, Southern Rocky Mountain Trench, and Columbia Mountains and Highlands (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Red-tailed Chipmunk, see Table 2. The Red-tailed Chipmunk is not considered, by Meidinger and Pojar (1991) to be a "representative species" in any of the biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

Both subspecies of Red-tailed Chipmunk found in the province (*T. r. ruficaudus* and *T. r. simulans*) are on the 1998 provincial red list of candidates for legal designation as endangered or threatened.

Habitat requirements

The Red-tailed Chipmunk prefers the margins of timberline meadows (Cowan and Guiguet 1973). The arboreal nature of this chipmunk restricts its distribution to below the treeline (Woods 1980). The Red-tailed Chipmunk prefers to have easy access to cover in a variety of forms ranging from shrub cover to fallen logs and brush piles (Rust 1946 as cited in Best 1993; Best 1993).

Food habits

The Red-tailed Chipmunk is typical of all chipmunks in its omnivorous food habits (Banfield 1974; Woods 1980; Best 1993) (see "Yellow-pine Chipmunk (2.11) - Food habits" for more details). This chipmunk also stockpiles non-perishable foods (usually seeds) in their underground den for consumption during the winter months (Best 1993).

Daily activity and movement patterns

The Red-tailed Chipmunk, like other chipmunks, is primarily diurnal in activity (Banfield 1974; Best 1993) (see "Yellow-pine chipmunk (2.11) - Daily activity and movement patterns" for more details). Most of the activities of this chipmunk is centered around feeding; either consuming or caching (Best 1993). Beg (1971) noted that spring-time foraging usually occurs on the forest floor, whereas, autumn foraging typically occurs within trees (as cited in Best 1993). Beg (1969) also reported that daily movements from burrows tended to be between 90 and 150 m, and occasionally reached as far as 270-m (as cited in Best 1993).

Seasonal activities and movement patterns

Like other chipmunks, the Red-tailed Chipmunk spends the majority of the year in an intermittent state of hibernation; from late October or November to late April or May (see "Yellow-pine Chipmunk (2.11) -- Seasonal activity and movement patterns" for more details) (Woods 1980). Copulation occurs soon after emergence from hibernation, and birth of an average five or six pups per litter follows a gestation period of about 30 days (Woods 1980). Beg (1971) noted that this chipmunk appeared to have an annual population cycle that peaked in August and declined until emergence from hibernation, when the cycle began again (as cited in Best 1993).

Other

This chipmunk can live together with the Yellow-pine (*T. amoenus*) and Least Chipmunks (*T. minimus*), because they each use a slightly different niche within the habitat. When found in the same area, these three species of chipmunks will likely be separated along elevation gradients; the Yellow-pine Chipmunk within the forest, the Red-tailed Chipmunk along the ecotone between forest and alpine, and the Least Chipmunk within the tundra alpine (Best 1993).

2.15 Red Squirrel, *Tamiasciurus hudsonicus* (Erxleben)

Synonyms

Sciurus hudsonicus, *S. hudsonicus petulans*, *S. hudsonicus picatus*, *S. hudsonicus richardsoni*, *S. hudsonicus vancouverensis*, *S. lanuginosus*, or *S. richardsoni* (Nagorsen 1990).

Other common names

Common squirrel, American squirrel, barking squirrel (Woods 1980), pine squirrel, or chickaree (Whitaker 1988).

Distribution within British Columbia

The Red Squirrel has a very broad distribution that covers the province except the southwestern and northwestern corners of the province, Vancouver Island, and coastal islands. It has been introduced to the Queen Charlottes (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988).

Ecoregions: This squirrel is found within all terrestrial ecoregions with the exception of one, the Lower Mainland (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Red Squirrel, see Table 2. The Red Squirrel is considered, by Meidinger and Pojar (1991) to be a "representative species" in all but four (Coastal Western Hemlock, Mountain Hemlock, Bunch Grass, or Alpine Tundra biogeoclimatic zones) of the 14 biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Red Squirrel is not in jeopardy, however is protected as a furbearer under the British Columbia Wildlife Act of 1982 (Stevens and Lofts 1988). It is on the Yellow list.

Habitat requirements

The Red Squirrel is an arboreal squirrel, and as such, require a forested habitat. This squirrel is able to inhabit deciduous habitats, but prefers boreal coniferous forests (Cowan and Guiguet 1973; Banfield 1974). Summer nests can be made within abandoned tree cavities or built outside of trees out of shredded bark and leaves (Stevens and Lofts 1988). Winter nests are generally found underground, usually among the protective roots of a large tree or stump (Banfield 1974; Woods 1980). Given a choice, the Red Squirrel prefers a habitat comprised of white spruce (*Picea glauca*) with large diameter stems and dense branching (Stevens and Lofts 1988).

Food habits

Banfield (1974) describes the Red Squirrel as an omnivore that will eat anything that will not eat it. Its diet includes fungi, berries, insects, forbs, and will prey upon several small mammals and birds (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988). By far, the most important food of the Red Squirrel is the seed of conifers (Banfield 1974). So important is conifer seed that population fluctuations are believed to be directly related to fluctuations in cone crops (Kemp and Keith 1970; Gurnell 1983; Sullivan 1987; Sullivan 1990). Winter caches of seed are stored (within the un-opened cones) underground or at the base of a tree in large piles called *middens* (Banfield 1974). This squirrel has been observed consuming from 47 (Dempsey and Keppie 1993) to 144 spruce cones per day (Brink and Dean 1966) depending on availability.

Daily activity and movement patterns

The Red Squirrel is diurnal in activity, with peaks of activity occurring soon after daybreak and just before dusk (Banfield 1974; Woods 1980). During cold weather, however, these squirrels restrict their activity to the warmest hours of the day (Banfield 1974). This solitary, arboreal rodent spends most of its time foraging within its defended territory (Banfield 1974). Food is usually obtained within the safety of trees. However, foraging will take place on the forest floor, especially near the base of trees (Banfield 1974).

Seasonal activities and movement patterns

The Red Squirrel is active year round. This squirrel may remain inactive for two or three days at a time during the coldest winter days, surviving on its cache of conifer cones, which were collected during the previous summer (Banfield 1974). This squirrel is polyoestrus. However, because of the short breeding season experienced within British Columbia, it tends to produces only one litter (average of four young) per year (Cowan and Guiguet 1973; Woods 1980). Breeding occurs in late April and parturition in May or early June (35 day gestation period) (Cowan and Guiguet 1973; Banfield 1974).

Other

The Red Squirrel is very vocal and will not hesitate to assault any intruder with a long repertoire of scolding calls. Banfield (1974) describes two of the more common calls as a metallic *chick-chick-chick* and a frenzied chattered *tcherrr*.

2.16 Douglas' Squirrel, *Tamiasciurus douglasii* (Bachman)

Synonyms

Sciurus douglasii or *S. molli-pilosus* (Nagorsen 1990).

Other common names

Chickaree (Cowan and Guiguet 1973; Nagorsen 1990), western chickaree, western red squirrel, yellow-breasted pine squirrel, Douglas chickaree (Woods 1980), or pine squirrel (Whitaker 1988).

Distribution within British Columbia

The Douglas' Squirrel is found in the southwestern corner of the province. More specifically, this squirrel inhabits the western slope of the Cascade and Coast Ranges; north to the head of Rivers Inlet, south across the international border, and east to Pinewoods area along the Hope-Princeton Highway (Cowan and Guiguet 1973).

Ecoregions: Lower Mainland, Pacific and Cascade Ranges, and Coastal Gap (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Douglas' Squirrel, see Table 2. The Douglas' Squirrel is considered, by Meidinger and Pojar (1991) to be a "representative species" in the Coastal Western Hemlock and Mountain Hemlock biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Douglas' Squirrel is on the provincial Yellow list.

Habitat requirements

The Douglas' Squirrel, like its close relative, the Red Squirrel (*Tamiasciurus hudsonicus*), is arboreal and therefore, requires very similar habitat to that of the Red Squirrel (see "Red Squirrel (2.15) -- Habitat requirements" for more detail). This squirrel has also adapted to living along edges or sometimes within clearcuts (Woods 1980).

Food habits

This squirrel's food habits do not differ significantly from that of the Red Squirrel (see "Red Squirrel (2.15) -- Food habits" for more detail).

Daily activity and movement patterns

Same as that of the Red Squirrel (see "Red Squirrel (2.15) - Daily activity and movement patterns" for more details).

Seasonal activities and movement patterns

Same as that of the Red Squirrel (see "Red Squirrel (2.15) - Seasonal activities and movement patterns" for more details).

Other

The distribution of Douglas' Squirrels meets, but does not overlap with that of the Red Squirrel (Banfield 1974).

2.17 Northern Flying Squirrel, *Glaucomys sabrinus* (Shaw)

Synonyms

Pteromys alpinus, *P. oregonensis*, *Sciuropterus alpinus fulginosus*, *S. alpinus zaphaeus* (Nagorsen 1990), *Sciurus hudsonius*, *S. sabrinus*, *S. labradorius*, *Pteromys canadensis*, *Sciuropterus yukonensis*, or *Glaucomys bullatus* (Wells-Gosling and Heaney 1984).

Other common names

Big flying squirrel or Canadian flying squirrel (Woods 1980).

Distribution within British Columbia

The Northern Flying Squirrel is common throughout all of British Columbia's mainland and some coastal islands (Cowan and Guiguet 1973; Stevens and Lofts 1988).

Ecoregions: This squirrel is found within all 22 mainland ecoregions of the province (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Northern Flying Squirrel, see Table 2. The Northern Flying Squirrel is considered, by Meidinger and Pojar (1991) to be a "representative species" in the Mountain Hemlock, Sub-boreal Pine--Spruce, Sub-boreal Spruce, and Engelmann Spruce-Subalpine Fir biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Northern Flying Squirrel is not in jeopardy, however, it is protected as a furbearer under the British Columbia Wildlife Act of 1982 (Stevens and Lofts 1988). It is on the provincial Yellow list.

Habitat requirements

The Northern Flying Squirrel is fundamentally arboreal and requires a forested habitat (Cowan and Guiguet 1973; Banfield 1974; Stevens and Lofts 1988). Because of the unique mode of mobility (gliding) often used by this squirrel, it prefers an open coniferous habitat with at least some tall trees (>17-m) from which to glide from (Cowan and Guiguet 1973; Stevens and Lofts 1988). Such habitat is commonly provided by over mature or old-growth successional stages.

Food habits

The Northern Flying Squirrel is an omnivorous squirrel that will eat a variety of foods including buds, fruits, seed, shrubs, mosses, forbs, insects, nestling birds, eggs, and carrion (Cowan and Guiguet 1973; Wells-Gosling and Heaney 1984; Stevens and Lofts 1988). However, the most important food items for this squirrel are lichens, especially during winter and early spring, and hypogeous fungi during summer and fall (McKeever 1960; Banfield 1974). Unlike other arboreal squirrels, the Northern Flying Squirrel does not store a large winter cache (Cowan and Guiguet 1973). Some speculate that they do not cache at all (Wells-Gosling and Heaney 1984). Winter food is usually provided by arboreal lichens, but can be obtained by tunneling through the snow to reach buried food, sometimes stealing from a Red Squirrel's (*Tamiasciurus hudsonicus*) cache (Wells-Gosling and Heaney 1984).

Daily activity and movement patterns

The Northern Flying Squirrel is nocturnal with a pronounced biphasic activity pattern observed during late summer; first appearing for two hours shortly after sundown and then again, for about an hour, a few hours before sunrise (Wells-Gosling and Heaney 1984). Activity is most common within trees. However, this squirrel is not confined to this arboreal habitat as it spends considerable time foraging on the forest floor at night (Banfield 1974).

Seasonal activities and movement patterns

The Northern Flying Squirrel is said to be active year round, however, Cowan and Guiguet (1973) report that this squirrel will enter a temporary state of torpor during extreme winter weather. This fundamentally solitary squirrel will aggregate with several other squirrels within one nest for warmth during extremely cold weather (Banfield 1974). Females are polyoestrus, however, more than one litter per year per female is rare (Wells-Gosling and Heaney 1984). Mating occurs from late March to early May, and birth (average litter size of 3) commonly takes place in May (gestation period of 37 to 42 days) (Cowan and Guiguet 1973; Wells-Gosling and Heaney 1984).

Other

The average gliding distance for the Northern Flying Squirrel is 19.7-m, but it has been observed gliding 90-m down a mountain side (Wells-Gosling and Heaney 1984). This squirrel has recently gained attention because of its importance as a food source for the Spotted Owl (*Strix occidentalis*). In a single year, one pair of Spotted Owls has been estimated to consume as many as 500 squirrels (Heinrichs 1983).

2.18 Gray Squirrel, *Sciurus carolinensis* Gmelin

Synonyms

Sciurus carolinensis leucotis, *S. leucotis*, *or S. migratorius* (Nagorsen 1990).

Other common names

Black squirrel (Woods 1980).

Distribution within British Columbia

In Canada, the Gray Squirrel is endemic to the eastern provinces. However, this squirrel has been introduced into British Columbia on two separate occasions. First in 1914, three or four pairs were introduced to the Stanley Park area in Vancouver (Cowan and Guiguet 1973), later, in the 1960’s, more were introduced into the Victoria area of Vancouver Island (Guiguet 1975). A close relative of the Gray Squirrel, the Fox Squirrel (*Sciurus niger*), has recently appeared in the extreme southern Okanagan Valley, and is presumed to have to have dispersed there from a nearby population (also introduced) in Okanagan County, Washington (Nagorsen 1990). The Fox Squirrel is not covered on an individual species level by this report, however, it is considered to be very similar to the Gray Squirrel in all respects.

Ecoregions: The Gray Squirrel is found only within the Lower Mainland and Eastern Vancouver Island ecoregions (adapted from Cowan and Guiguet 1973; Demarchi 1988).

Biogeoclimatic zones: For an indication of which biogeoclimatic zones are inhabited by the Gray Squirrel, see Table 2. The Gray Squirrel is not considered, by Meidinger and Pojar (1991) to be a "representative species" in any of the 14 biogeoclimatic zones (adapted from Wildlife Branch 1989).

Status

The Gray Squirrel is on the provincial Yellow list.

Habitat requirements

The Gray Squirrel is an arboreal squirrel, and as such, requires a forested habitat. Unlike its close cousins in the *Tamiasciurus* genus, this squirrel requires a deciduous, or mixed, forest habitat (Cowan and Guiguet 1973; Banfield 1974). Therefore, this squirrel thrives in the ornamental, deciduous urban forests where it has been introduced. Deciduous habitat is preferred for its forage potential, whereas, coniferous habitat is preferred for its cover (Banfield 1974).

Food habits

The Gray Squirrel is omnivorous, eating buds, leaves, fruits, seeds (mostly from deciduous trees), insects, and bird eggs (Cowan and Guiguet 1973; Banfield 1974). Their preference for these food items changes with availability and phenological stage of the vegetation; swelling buds are fed upon during early spring, flowers and samaras in late spring. A variety of fruits (especially nuts) are eaten during summer and fall for forming a thick layer of fat (Banfield 1974; Woods 1980). This squirrel also stockpiles a winter supply of food in underground storage piles called *middens*.

Daily activity and movement patterns

The Gray Squirrel is diurnal with two peaks of activity, the first between 7 and 8 a.m. and the second between 3 and 6 p.m., separated by a time of rest around midday (Banfield 1974). Activity is decreased during inclement weather to the point where during extreme winter conditions the squirrel does not emerge from its winter nest for days at a time (Banfield 1974).

Seasonal activities and movement patterns

The Gray Squirrel is active year round and survives a large portion of the winter on its cache of food, and on its fat reserves (Banfield 1974). This polyoestrus squirrel can produce two litters per year, with an average of three pups per litter; the first in May and the second in July. The gestation period is 44 days) (Cowan and Guiguet 1973; Woods 1980).

Other

This squirrel will readily take to the water, and has been observed swimming great distances in order to reach new grounds (Banfield 1974; Woods 1980).

Table 2. Species distribution relative to biogeoclimatic zones [a] *

Species	Biogeoclimatic Zones													
	CDF	CWH	MH	BG	PP	IDF	ICH	MS	SBPS	SBS	ESSF	BWBS	SWB	AT
M-OCPR	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜			☜
M-OCCO		☜	☜								☜	☜	☜	☜
M-SPCO				☜	☜	☜	☜	☜	☜	☜	☜			☜
M-SPPA		☜	☜				☜			☜	☜	☜	☜	☜
M-SPLA					☜	☜	☜	☜		☜	☜			☜
M-SPSA		☜		☜	☜	☜		☜			☜			☜
M-MAFL			☜	☜	☜	☜	☜	☜	☜		☜			☜
M-MAMO		☜	☜	☜		☜	☜	☜	☜	☜	☜	☜	☜	☜
M-MACA		☜	☜			☜	☜	☜	☜	☜	☜	☜	☜	☜
M-MAVA		☜	☜											☜
M-TAAM	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜			
M-TAMI										☜	☜	☜	☜	☜
M-TARU						☜	☜	☜			☜			
M-TATO	☜	☜	☜			☜		☜			☜			
M-TAHU	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	
M-TADO	☜	☜	☜											
M-GLSA	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	☜	
M-SCCA	☜	☜												

☜ - occurrence

[a]adapted from Cowan and Guiguet (1973), Banfield (1974), Meidinger and Pojar (1991), and British Columbia Ministry of Forests (1988)

Abbreviations for Biogeoclimatic zones: CDF=Coastal Douglas-fir; CWH=Coastal Western Hemlock; MH=Mountian Hemlock; BG=Bunchgrass; PP=Ponderosa Pine; IDF=Interior Douglas-fir; ICH=Interior Cedar-Hemlock; MS=Montane Spruce; SBPS=Sub-Boreal Pine-Spruce; SBS=Sub-boreal Spruce; ESSF=Engelmann Spruce-Subalpine Fir; BWBS=Boreal White and Black Spruce; SWB=Spruce-Willow-Birch; AT=Alpine Tundra (Meidinger and Pojar 1991).

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 target species, and the objectives of the inventory. Since most provincially-funded wildlife inventory projects deal with terrestrial-based wildlife, the terrestrial Ecosystem Field Form or the Ground Inspection Form, developed jointly by Ministry of Forests (MOF) and Ministry of Environment, Lands and Parks (MELP) can be used when appropriate. Although both of these forms have been used primarily in terrestrial ecosystems, they can also be used in wetlands to describe emergent vegetation and other relevant attributes. Further information about standard habitat data collection is available in the introductory manual, *Species Inventory Fundamentals, No. 1*.

3.1.2 Time of survey

Appropriate season of sampling is largely dependent on the species being surveyed. For example, it would not be appropriate to sample animals such as ground squirrels, chipmunks, or marmots during periods of hibernation. It is important to understand some fundamental biology and ecology of the species being sampled (see ‘Inventory Group’, section 2, for more detail) as knowledge of the timing of hibernation, breeding season, and juvenile dispersal will aid in choosing an appropriate time for sampling.

3.1.3 Survey Design Hierarchy

Pika and sciurid surveys follow a survey 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 fixed-width transect survey. A survey set up following this design will lend itself well to standard methods and RIC data forms.

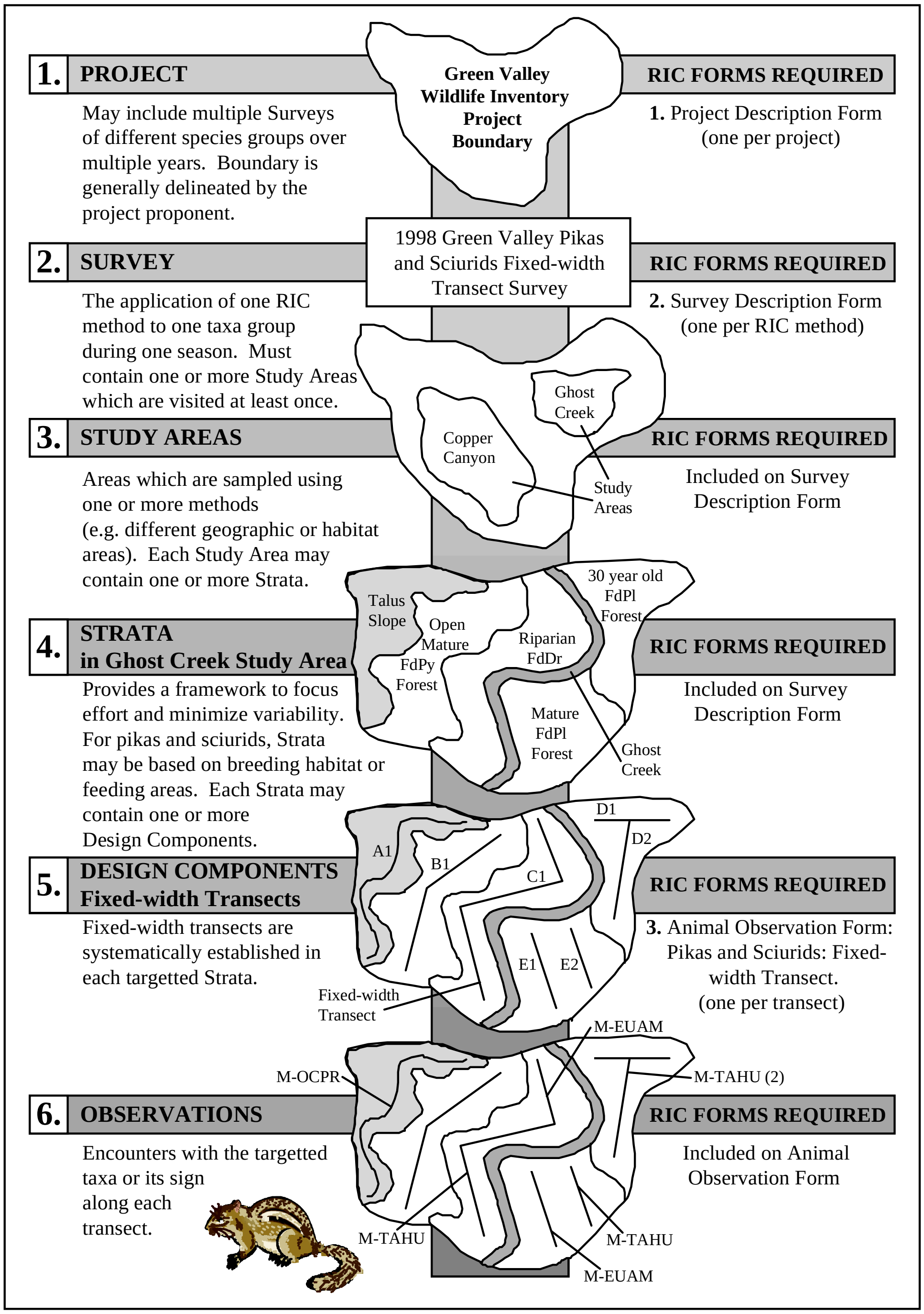

Figure 1. RIC species inventory survey design hierarchy with examples.

3.2 Inventory Surveys

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

Table 3. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Type	Forms Needed	Intensity
Direct observation and sign sampling	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Pikas and Sciurids • Animal Observations Form- Pikas and Sciurids Fixed-width Transect • Ecosystem/Habitat Form (see *Species Inventory Fundamentals*)	• PN • RA
Mark-release / recapture	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Pikas and Sciurids • Capture Form - Pikas and Sciurids • Animal Observations Form- Pikas and Sciurids Capture • Ecosystem/Habitat Form (see *Species Inventory Fundamentals*)	• AA

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

3.3 Presence/Not detected and Relative Abundance

Recommended method(s): Direct observation and sign sampling using fixed-width or line transects and when appropriate point count stations.

Because species within the inventory group pikas and sciurids are all quite visible and/or vocal, sampling animal sign or observing the animals directly is the most appropriate method of determining presence/not detected and relative abundance. Note: information pertaining only to presence/not detected surveys are denoted with an astrix (*).

It is important that the main assumptions of relative abundance surveys are met. If they are, then each replicate surveys should show (on average) the same relative bias allowing calculation of trends and comparison between areas. It should be emphasized that it may be very difficult to meet these assumptions unless survey efforts are standardized and observers are trained appropriately. The main assumptions are:

1. Identical or statistically comparable methods are used when the objective of inventory effort is to compare between areas or to monitor trends in one area over time.
2. Environmental, biological, and sampling factors are kept as constant as possible to minimize differences in survey bias and precision between surveys.
3. Surveys are independent; one survey does not influence another.

3.3.1 Direct observation and sign sampling

Direct observation

Estimating animal abundance from direct observations of animals is a particularly relevant method for censusing pikas and sciurids, as many of these species are easily observed in their natural habitat. The probability of observing these animals is increased by the fact that many of them announce their presence by conspicuous vocalizations. Pikas, tree squirrels, ground squirrels and marmots are all very vocal (see section 2, ‘Inventory Group’, for more details). Animal vocalizations may be detected by passive observation. However, many investigators increase the probability of detecting animals by evoking a vocal response from the animals with an acoustic-cue, such as a tape recording or whistle call (Leung 1991; Lishak 1982). Methods of observation vary depending on the species being sampled and the objectives of the study.

The assumptions for a sampling design based on the direct observation are: 1) the sampled population is assumed to be closed to significant population changes due to deaths, births, immigration, and emigration during the sampling period; 2) Equal sightability or observability is assumed (*i.e.*, all animals have the same probability of being observed). A unique problem for the observation method is the chance that an animal will be observed more than once during a single sampling period. This can be particularly true when trying to distinguish a number of animals which may be calling, but are difficult to see. It is not possible to avoid this problem; however, conscientious efforts should be made to keep track of which animals have been sampled.

* These assumptions can be relaxed when direct observation methods are used for presence/not detected surveys since no estimate of population size is made from the data. However, it is still essential that effort in terms of survey time and area covered is standardized so that comparison between areas is possible.

The level of accuracy possible from a direct observation method depends on how closely the required assumptions are met or approximated during sampling. The most important factor that will likely determine the feasibility of this method is the observability of the animals being sampled. For example, if the animals are so elusive that they are only rarely seen or heard, this method will not yield very accurate estimates of abundance. This precision of surveys for some of these more cryptic sciurid species is often quite low due to low sample sizes, and a high degree of within-site variability. It is suggested that absolute abundance methods be used if comparison between areas or solid documentation of trends is an objective of survey efforts. As discussed below, transects should always be replicated at the same site to determine precision if a relative abundance survey is being conducted. These results should be coupled with power analysis to determine optimal survey sample sizes.

Replicating counts from an individual site can identify the influence of within-site variability on results using the methods of Link *et al*. (1997). The analysis of Link *et al*. (1997) was mainly aimed at songbird populations; however, the general results are applicable to all wildlife surveys. Within-site variability can be defined as variation due to factors such as differences between observers, and short-term variation in population size at a count station or monitoring site. This is not to be confused with between-site variability, which is due to large-scale differences in the spatial distribution of species, and forms the basis for most experimental designs. In general, Link *et al*. (1997) found that if the proportion of within site variation is large, and the cost of replicating a site is small compared to setting up a new site, then it is optimal to replicate counts. If the proportion of within site variation is small, and the cost of replicating a site is equal to that of setting up a new site, then it is optimal to not replicate. Not surprisingly, Link *et al*. (1997) found that counts for birds with lower abundance had the highest percentage of within count variation, which highlights the statistical problem of estimating abundance for rare species. It is suggested that biologists consult Link *et al*. (1997) when designing monitoring studies, especially for species that show low abundances.

<u>Advantages:</u>

- Does not require expensive trapping apparatus;
- Fast method of sampling;
- Appropriate for sampling very large areas;
- Minimal disruption to population;
- May allow for behavioural observations; and
- Appropriate for sampling rare and endangered species

<u>Disadvantages:</u>

- Only appropriate for visually obvious species or species where individuals can be distinguished by call;
- Results can be easily biased by different observation skills among investigators; and
- Only provides relative abundance estimates unless combined with some marking program

Animal Sign

Many animals can be detected by the sign they produce within their habitat. An animal sign is any animal attribute that reveals its presence, without the need for capturing or seeing the animal directly (*e.g.*, deer pellets, animal tracks, and conspicuous residents such as beaver dams). The primary advantage for using animal sign is that it is often easier to sample than it is to sample the animal directly.

The use of animal sign is particularly relevant for the study of pikas and sciurids as many of these species produce obvious signs within their habitat. For example; pikas produce large hay stacks; Red and

Douglas' Squirrels create conspicuous winter caches (middens); and ground squirrels often leave mounds of dirt by the main entrance to their underground burrows (see section 2, 'Inventory Group', for more details). Vocalizations may also be a useful "sign" of an animal's presence, even when individuals can not be distinguished and counted. Pikas, tree squirrels, ground squirrels and marmots are all very vocal (see section 2, 'Inventory Group', for more details). Passive listening for calls may provide evidence of an animals current presence, and more active methods, such as playing a tape recording or sounding a call, can increase the probability of evoking a vocal response (Leung 1991; Lishak 1982).

All of these signs can yield useful estimates of relative abundance within a Study Area. For example, if sample 'A' had six squirrel middens and sample 'B' only had two, it can be estimated that sample 'A' has a greater abundance of squirrels relative to sample 'B'.

Note that pikas and squirrels use the same hay pile areas, or midden areas each year and so it may be difficult to use sign surveys for relative abundance data. In some cases, these signs of use will look similar if the territory is occupied or not occupied. Also, it may be difficult to tell the age of scat especially in dry environments which will positively bias abundance counts if all scat groups are counted especially if the data are to be used for trend analysis. Therefore, blindly using sign surveys as an index of abundance may lead to erroneous results. Some of these problems could be overcome by counting the same areas each year and clearing away old scats or hay piles, but middens are too permanent for this approach.

The assumption that is most important for methods involving sampling of animal sign is that all sign must have an equal chance of being sampled. This assumption is best approximated by ensuring that equal effort is spent searching for animal sign within all samples and throughout the sampling period.

The level of accuracy possible for abundance estimates from the sampling of animal sign is largely dependent on how closely the above assumptions are met. A significant amount of bias can unintentionally affect the data because of the objective nature involved with sampling sign. This bias may be reduced by training personnel as to the correct identification of sign and appropriate methods of searching for sign.

* Assumptions can be relaxed if all that is needed is a single observation of the species for a presence/not detected survey. However, efforts should still be made to standardize searches to allow valid comparison of the distributions of animals in different areas.

<u>Advantages:</u>

- Much faster than capture methods;
- Appropriate method for sampling very large areas;
- Less expensive than capture methods;
- Fewer person hours required;
- Little field equipment required; and
- Should not affect the social structure of the sampled population.

<u>Disadvantages:</u>

- Not appropriate for estimates of absolute abundance and
- Difficult to maintain consistency among investigators.

Office procedures

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

- Obtain relevant maps of 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). Any map which is used to record data should be referenced to NAD83.
- Consult local experts and naturalists for suggestions.
- Select species to be surveyed and plan timing of surveys.
- Outline the Project Area on a map and 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.
- Select Study Areas based on existing data, personal experience, and topographic maps and that are likely to have suitable habitat.
- Locate capable Field Personnel.

Sampling design

Stratified systematic sampling using transects or in some cases, point count stations.

Transects

Wide ranging species, such as tree squirrels, chipmunks, and ground squirrels are often observed along a single long, or several short transect lines (straight or meandering). Total length of transect line sampled will vary with each study. Observations are made continuously along a transect line.

Transects should always be stratified by habitat type to minimize variance caused by differences in sightability of animals (due to habitat differences) along transects.

The area covered by a transect line will vary depending on the visibility within different habitats (*i.e.*, visibility is less within a dark densely forested habitat than within an open grassland habitat). To avoid the problem of different area coverage by equal length transect lines, the area sampled needs to be determined for each transect line.

Fixed-width (strip) transects

A fixed-width (strip) transect can be used so that the area sampled along a transect can be determined. Fixed-width transects use predetermined boundaries, outside of which observed animals are not recorded. This predetermined boundary should be representative of the visibility within the Study Area.

A fundamental assumption of a fixed-width (strip) transect is that an equal proportion of animals is detected in each strip transect. If the proportion detected is known, absolute density estimates can be obtained (although this will likely not be the case in this survey). If the proportion detected is not known, relative abundance can be estimated, as long as the probability of detection is assumed to be constant.

If fixed-width transects are to be used for relative abundance methods then it is important that an optimal strip width be determined for the species being investigated. Researchers should search the literature to determine strip widths used on other surveys of a species in similar habitat types. If this is not available then it is recommended that line transect methods (see below) are used initially in a pilot study to obtain a general idea of the shape of the detection function of the species being investigated. A detection function can be visually plotted by a histogram of relative frequencies of observations of a species at different distances from the center line of the transect. Usually, the majority of observation will occur close to the line and then will fall off at some distance from the line. The width at which the relative frequency drops off is approximately the optimal strip width for a transect. See Buckland *et al*. (1993) or Krebs (1989, page 114) for more details on detection functions.

* These assumptions can be relaxed for presence/not detected. Animals/sign observed outside of the fixed-width are still recorded, but a note that they were outside the boundary should be made.

Line transects

A line transect approach should be considered if the assumptions and sample size requirements of this method can be met. With a line transect, exact measurement of the perpendicular distances of animals from the center of the transect are taken. This allows an estimation of the detection probability of animals, as well as an estimate of density. Line transects have the following assumptions.

1. *Objects on the line or point are detected with certainty*. An observer should record animals that are detected in front of the line, as well as to the sides. Having two observers will aid in this process.
2. *Objects are detected in their initial location*. This assumption will generally be met as long as animals are not flushed during the search process.
3. *Measurements are exact*. New inexpensive laser rangefinders will aid in making exact measurements. Some units allow exact measurement of distances using a “gun sight” monocular. They will give accurate estimates from non-reflective surfaces such as trees.

Note that the only difference between fixed-width and line transects in terms of data requirements is that the location of an animal must be recorded with strip transects. The major constraint to the line method is sample size. Buckland *et al*. (1993) states that at least 60 animals should be sighted for the use of distance models in program DISTANCE.

* These assumptions can be relaxed for presence/not detected. Animals/sign observed should be recorded even when exact location or distance is not know.

General

It is important not only to determine the optimal width but also the optimal length of transects. This problem is identical to that discussed for quadrat sampling in Krebs (1989, page 64). This problem does not arise with line transects in which the recommendation of n > 60 should be followed.

Without the knowledge of area sampled, it becomes very difficult to compare results from different transects. Detailed information regarding the transect method of sampling can be found in Anderson *et al*. (1976b), Burnham *et al*. (1980), and Hatler (1991). These sources can be consulted for further information on transect sampling.

Since it is assumed that the probability of detection is constant, two observers or one observer with a tape recorder (to record data) are recommended to ensure adequate coverage of the strip area during a sight transect. It is not recommended that sign transects be conducted at the same time as sight surveys for the observers might be distracted while looking for sign and may not observe the strip area in a consistent fashion.

Point Counts

Transect methods may not be optimal for habitats that are highly patchy and discrete. An example of this type of habitat is talus piles inhabited by pika and marmots which are shaped irregularly and are separated by uninhabitable forest or meadow. For this type of habitat, a point count method should be used. The observer records animal observations from one point for a specified amount of time (if a direct observation survey) or sign for a specified distance around the center point (for a sign survey). The number of points in a talus slope should be determined by the relative area of the talus patch as discussed in the stratification section below.

Stratification

*For presence/not detected surveys it is optimal to concentrate survey efforts in the best habitats or high strata where the probability of species detection will be maximized.

For relative abundance surveys, it is important that transects and point count stations always be stratified by habitat type to determine optimal habitat and to minimize variance caused by differences in sightability of animals (due to habitat differences). Systematic sampling within the strata is then used to ensure equal effort between surveys. Examples of this design are:

- *Highly patchy habitats.* Species such as pikas and marmots, that are usually found only within very specific habitat and usually in small groups are most effectively investigated by concentrating sampling efforts on the occupied habitat (*i.e.,* pika surveys on intermittent talus slopes interspersed on a hillside). Specific habitats, such as talus areas, are identified from preliminary recognizance (using a systematic sampling design, such as transect lines, to locate the animal's habitat) and the approximate area of each talus patch is determined. Replicated "point count" stations are assigned to patches so that each patch has the same number of stations per unit area of talus. Stations are monitored for set periods of time during the morning and evening hours when activity levels are highest. This process is replicated on a daily basis preferably during the latter part of the summer when hay piles of animals are also evident. The location of stations is recorded if yearly monitoring is an objective of the survey effort.
- *Less patchy habitats* (*i.e.,* surveys for squirrels or chipmunks in a uniform forest): Straight transect lines are planned with the length of the transect being proportional to the size of the forest habitat to be surveyed. The amount of time to complete a transect is also recorded. The transect route and time is recorded if yearly monitoring is an objection of the survey effort.

The actual design of a survey will obviously depend on project objectives and the size of area to be surveyed. In all cases, effort and environmental, observer, and biological factors should be kept as constant as possible if the relative abundance estimates are to be statistically accurate. In all cases, surveys should be replicated to allow estimation of survey precision.

Sampling effort

* It is suggested that investigators take advantage of the similarity in presence/not detected and relative abundance methods to help define optimal sample effort for presence/not detected methods. In addition, presence/not detected surveys can provide valuable preliminary survey data for relative abundance methods if methods are identical. Theoretically, a plot of the number of species detected versus the number of replicated transects should asymptote when all species have been detected in an area. This will be the optimal search effort to determine presence/not detected for that specific area. A critical assumption of this procedure is that each presence/not detected survey is a statistical *replicate* of a relative abundance survey. Methods for determination of optimal survey effort for presence/not detected are discussed in the section on statistical analysis and in section 5.2.1 of the *Species Inventory Fundamentals, No. 1.*

The optimal amount of survey effort will depend on project specific objectives, the density of animals in the Study Area, and other factors. Therefore the procedure outlined below should be conducted for each particular Study Area to be investigated.

The sample unit in this survey is the cumulative count of animals encountered, or sign that was encountered in a survey effort. The importance of sampling effort will be very dependent on the nature of the actual objectives of the study. The following steps are suggested to determine optimal sampling effort be used as part of planning a study.

1. *Define objectives*: What will be the ultimate use of results of the inventory effort?
2. *What statistical test will you use?* Consult *Species Inventory Fundamentals, No. 1*, section 5.3 to answer this question.
3. *Collect preliminary data:* Conduct a few replicated pilot surveys possibly as part of a presence/not detected survey.
4. *Conduct a power analysis*. If a survey is replicated then the precision of the survey can be estimated. This will allow a power analysis to be done that will be particular to the statistical test identified in point 2. Many of the newer power analysis packages are very easy to use and can be loaded on to a laptop computer. See *Species Inventory Fundamentals, No. 1*, section 5.3 and Appendix G for more details on power analysis.

Observer bias: It should also be emphasized that proper training and standardization of observers is essential for unbiased and precise relative abundance surveys. Biologists should be tested in terms of the ability to detect animals and animal sign. The knowledge of optimal habitat, and animal habits will greatly influence sightability. This is especially noteworthy for animals such as pikas which exhibit highly defined habitat preference. It is suggested that observers are randomized in Study Areas to minimize bias in any particular Study Area. In some cases it may make sense to replicate observer efforts across strata and stratify the final analysis by observer to allow testing for observer effects. In addition, the methods of Link *et al.* (1997) can also be used to account for within-site variability.

Time requirements

* Presence/not detected: Number of person hours required for presence/not detected inventory is difficult to predict as it depends on the sampling intensity and size of area to be sampled. However, long term sampling designs are not required for precise estimates of presence/not detected inventory, in fact, single samples may often be adequate. Of course, to determine the presence of a rare or inconspicuous species, more sampling time will be required than if only common or conspicuous species are to be sampled.

Relative abundance: The time required for a sampling method designed to inventory the relative abundance of pikas and sciurids depends on the sample intensity and size of area to be sampled. The sampling time will also depend on what features are to be sampled. For example, Bouffard (1982) recommends that 20 minutes be spent listening for the vocalizations of tree squirrels every 250-300 m. However, if squirrel middens were the sampling objects rather than squirrel vocalizations, much less time would be spent .

Timing of Sampling

The timing of sampling depends on the species that is expected to be sampled and on what sign is being sampled.

If sampling animal vocalizations, survey during the season and time of day when the animals are most actively vocalizing. In general, this is during the breeding season (early spring for most pikas and sciurids) and in the early morning.

Sampling physical sign is less affected by time of day than are vocalizations because of its relatively permanent nature. However, time of year may still influence the success of sampling physical sign. For example, the hay piles created by pikas are most effectively sampled during late summer or early fall, as this is the time of year when hay piles are biggest and more easily observed. Also, some sign can be completely concealed by a blanket of snow during the colder months. However, this same snow cover may increase the probability of observing some sign, such as animal tracks.

Personnel

Field personnel must be able to identify species by sight and/or by their sign. Identification of pikas and sciurids can be aided by instruction from an experienced worker or by pictorial field guides. Species descriptions (including drawings and/or pictures) from books such as The Mammals of British Columbia (Cowan and Guiguet 1973) and The Mammals of Canada (Banfield 1974) would be valuable.

Equipment

- Water-proof data book and dataforms
- A tape recorder with good batteries and back-up batteries if an investigator is working alone, as it is difficult to search a transect line or animal sign, and pause every time an entry needs to be made into a data book (these pauses waste time and break the investigator's concentration).
- Field guides for identification of animals or animal sign.
- Compass
- A pair of binoculars or sighting scope for the observation of animals from a distance.
- Measuring tape and/or premeasured sections of rope (*e.g.,* 10 or 20 m sections) or a hip chain
- General outdoor attire, such as raingear, boots (possibly chalk boots if sampling a site that has considerable amounts of natural or logging slash).

Field procedure

- Many investigators increase the probability of sampling animals by evoking a vocal response from the animals with an acoustic-cue. For example, the sampling of ground squirrel vocalizations are improved when a tape recording of the squirrel's calls are played back on a loud speaker (Lishak 1982). Also, Leung (1991) found the periodic sounding of a high pitched whistle to be an effective way of increasing the observability of ground squirrels.

Transects

- If Study Areas are to be resampled then the transect lines should be flagged with coloured flagging tape to facilitate future relocation. Tie flagging tape to tall shrubs or branches of trees. If no such vegetation is available, flagging may be attached to wooden stakes or re-bar that has been driven into the ground with a hammer.
- Identify transect lines with a permanent felt marker on the flagging tape. It is also important to draw a sketch map of the Study Area that indicates directions to the Study Area, outline of Study Area, prominent features within the Study Area (*e.g.,* a large snag, creek, swamp, etc.), and location of transect lines so that other investigators may locate the appropriate site for future sampling.
- Sample along straight, parallel transect lines that are divided up into 10 m segments (Figure 1). This is best accomplished by a two-person team. Grouping the observations this way can yield valuable information about the spatial distribution of animals (*e.g.,* habitat preference) throughout the Study Area, provided that information about the habitat was recorded for each of the 10 m segments.
- With the aid of a compass, one person (X) gives direction to the other (Y) as s/he stretches a 10 m section of rope between themselves.
- Do a visual search for the animals or their sign along these transect segments (it is not recommended that sight and sign surveys be conducted simultaneously). If more than one site is to be sampled, sampling efforts should remain constant if valid comparisons of species richness between sites are to be made.

- Sign surveys: Hatler (1991) used a 2 m strip (1 m on either side of the transect) to monitor biodiversity sign. Note: it may be difficult to use sign surveys for relative abundance data or even determine whether an animal is currently occupying an area or not because pikas and squirrels use the same hay pile areas, or midden areas each year. In some cases, these signs of use will look similar if the territory is occupied or not occupied. Also, it may be difficult to tell the age of scat especially in dry environments which will positively bias abundance counts if all scat groups are counted especially if the data are to be used for trend analysis. Therefore, blindly using sign surveys as an index of abundance may lead to erroneous results. Some of these problems could be overcome by counting the same areas each year and clearing away old scats or hay piles, but middens are too permanent for this approach.
- Direct observations of animals: a fixed-width transect or a line transect can be used
    - Fixed-width transects. Strip width will depend on the species and habitat being searched. Use the literature to determine width or use a line transect method to obtain a detection function for that species and habitat.
    - Line transects. Use line transects if the required assumptions and sample size can be met.
- * For presence/not detected surveys, assumptions and guidelines around these transect methods can be relaxed. Record all observations, indicating whether they were in the strip area or not.
- Repeat until the desired length of transect has been sampled.
- If a one person rather than a two-person team is used, then a hip-chain may take the place of the 10 m section of rope, and a tape recorder may take the place of the data book and recorder (Hatler 1991).

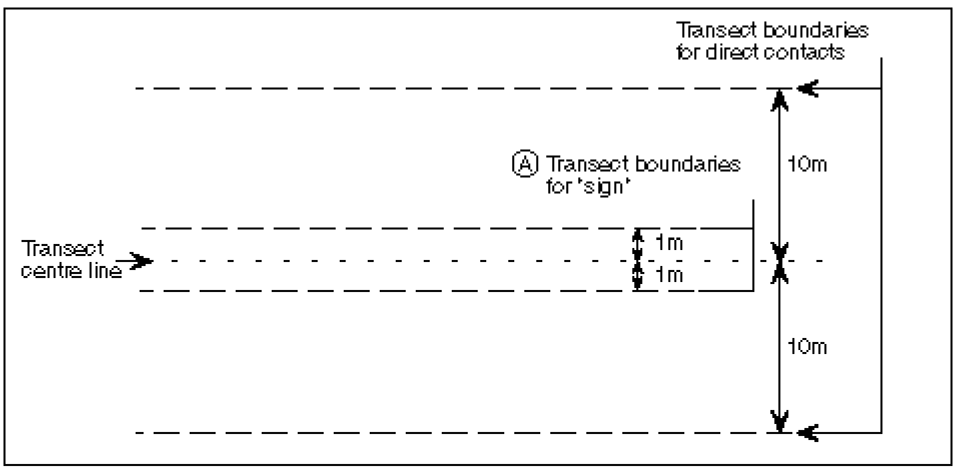

Figure 2. An example of a straight line fixed-width transect layout illustrating direct animal observation and sign sampling (adapted from Hatler 1991). Actual transect width may vary.

Point Count Stations

- For species such as pikas and marmots, that are usually found only within very specific habitat and usually in small groups, use a systematic sampling design, such as transect lines, to locate the animal's habitat (*e.g.*, a talus slope), and to determine presence/not detected*.
- Relative abundance. Once appropriate habitats have been located, concentrate sampling efforts within the appropriate habitat using point count stations.
- If Study Areas are to be resampled then point count (observation) stations should be flagged with coloured flagging tape to facilitate future relocation. Tie flagging tape to tall shrubs or branches of trees. If no such vegetation is available, flagging may be attached to wooden stakes or re-bar that has been driven into the ground with a hammer.

- Identify point count stations with a permanent felt marker on the flagging tape. It is also important to draw a sketch map of the Study Area that indicates directions to the Study Area, outline of Study Area, prominent features within the Study Area (*e.g.*, a large snag, creek, swamp, etc.), and location of point count stations so that other investigators may locate the appropriate site for future sampling.
- Sign surveys: look for animal sign for a specified distance around the center point.
- Direct observations of animals: record animal observations from this point for a specified amount of time.

Data analysis

****Presence/not detected***

- Depending on the approach taken, analysis of presence/not detected survey data may be as simple as compiling a list that indicates which species were present at each site. It is also important to include a map which shows Study Area boundaries, Design Components, and indicates where detections were made. Remember that just because a species was not observed does not mean that it is absent from the sample area. However, the greater the sampling effort, the more confidence one has about which species are present and which are absent.
- Higher quality, more conclusive analysis to satisfy different objectives may also be conducted. The actual statistical technique to be used will depend on the objective of the inventory effort. Table 1 below highlights suggested analysis methods for the given RIC objectives.

Table 4. RIC objectives and analysis methods for presence/not detected data.

RIC Objective	Analysis methods	Program
• Document species range	• Analysis to ensure adequate effort. Negative binomial estimate[1]	• See *Species Inventory Fundamentals, No. 1,* section 5.2
• Determine habitat associations	• Logistic regression	• Generic statistical analysis software
• Detect change in distribution over time	• Use relative abundance methods and regression techniques.	• Generic statistical analysis software

[1] See *Species Inventory Fundamentals, No. 1,* section 5.2, for more details on negative binomial methods.

Quantifying probability of detection: The main purpose of these methods is to document species geographic ranges. From a statistical point of view it is important to attempt to quantify the detection probability (as a function of population density, population spatial distribution, detection probability, sampling effort, and other covariates) for a species to allow a general estimate of the optimal amount of effort needed for surveys. Also, if an attempt is made to quantify probabilities of detection, a more statistically conclusive statement can be made about possible reasons for not detecting a species as opposed to a simple “none were found” conclusion. A simple way to estimate probability of detection is through the use of the negative binomial distribution with data from relative abundance surveys. This procedure is detailed in *Species Inventory Fundamentals, No. 1,* section 5.2.

Documenting changes in species distributions: If the objective is to detect change in geographical distribution over time, a more intensive survey regime using relative abundance methods is recommended. This will allow a probability level to be associated with changes in distribution or apparent local extinction. A conclusion that species have become extinct in an area using presence/not detected methods will be difficult given that no estimate of survey precision is possible using current methods. More exactly, it will be difficult to determine if a species is not detected is due to low sample efficiency or actual demographic extinction.

Documenting habitat associations: If describing habitat associations is an objective, it will be important to document habitat types at the scale of pikas and sciurid home ranges.

Relative Abundance

Comparisons of species richness between two or more sites is only possible if equal effort was spent sampling within each of the sites. Information about the species frequency is necessary if sampling for relative abundance. For determining relative abundance, summarize the data in terms of observations per unit effort (*i.e.*, area or time). For example, an average of 15 squirrels were observed per hour sampling, or an average of two squirrel middens were observed per transect segment, or a total of 25 squirrels were observed on a 500-m transect, and so on. If sampling efforts are equal among samples, relative comparisons can be made.

The quantification of sampling intensity and effort is fundamental to the use of indices and relative abundance measures. This way the assumption of equal bias of surveys between areas and over time can be met. In addition, the usefulness of indices depends on the precision of estimates. It is strongly recommend that power analysis procedures be integrated into the study design of all these techniques. As described in *Species Inventory Fundamentals, No. 1*, Appendix G, programs such as MONITOR, POWER AND PRECISION, and NQUERY are user friendly, and can be used easily in an adaptive fashion to calculate sample sizes needed for the ultimate analysis questions.

If studies are designed appropriately (see *Species Inventory Fundamentals, No. 1*, section 5.3) the following general analysis methods can be used (Table 2).

Table 5. RIC objectives and analysis methods for relative abundance data

Objective	**Analysis method**[1]	**Programs**[2]
• Trends in abundance over time	• Sample methods • Regression techniques • Power analysis	• Generic statistical packages • MONITOR
• Comparison in abundance between areas	• ANOVA, non-parametric method • Power analysis	• Generic statistical packages • Power analysis software
• Determine whether habitat modifications have altered population size	• T-test or non-parametric method • Power analysis	• Generic statistical packages • Power analysis software

1See *Species Inventory Fundamentals, No. 1*, section 5.3 for more details on analysis techniques

2See *Species Inventory Fundamentals, No. 1*, appendix G for more detail on software packages

It may be possible to use program DISTANCE with point count and transect data to allow estimates of probability of detection and actual density. Program DISTANCE is quite powerful, and employs parsimonious and robust modeling techniques to allow density estimates from point count data. However, it also has restrictive sampling assumptions and is statistically complex. It is suggested that a statistician trained in distance methods be contacted if this method is considered. See *Species Inventory Fundamentals, No. 1*, appendix G for more details on program DISTANCE.

Difficulties with count data: One inherent problem with count data is that it is rarely normally distributed making the applicability of parametric methods with raw data risky, especially if sample sizes are low. A detailed discussion of analysis of count data is presented in *Species Inventory Fundamentals, No. 1*, Section 5.3.

Trend analysis: The basic method for determination of trends is linear regression. There are a variety of refinements to the linear regression technique that can be used with data dependent on sampling assumptions and other characteristics of the data. *Species Inventory Fundamentals, No. 1*, Section 5.3 provides a detailed discussion of these techniques.

Comparison between areas: Parametric, data based modeling, and randomization methods can be used to compare areas if surveys are conducted concurrently. If surveys are conducted non-concurrently (such as different years) then the results might be biased by population fluctuations. See *Species Inventory Fundamentals, No. 1*, Section 5.3 for a thorough discussion of analysis of count data.

Habitat based inference: Logistic regression or similar methods can be used for determining habitat associations but this approach requires that habitat units be the primary sample unit as opposed to population units.

3.4 Absolute Abundance

Recommended method(s): Mark-release-recapture (MMR)

3.4.1 Live trapping/Mark-release-recapture

Any process that involves the live capture, marking and release of an animal, followed by a subsequent recapture of the marked animal, is referred to as a mark-release-recapture method (MRR). In general, live traps are either solid sided box traps or mesh cage-like traps. Some examples of commonly used live traps are: Longworth Live Trap, Bolton Live Trap, Sherman Traps, Tomahawk Live Traps and Havahart Live Traps.

The designs of all of these live traps are very similar. A spring-loaded door or gravity-fed door, in the case of the Longworth trap, is triggered to close by the weight of a visiting animal stepping on a treadle mechanism (a wire or wire attached to a stepping plate). Several sizes of Shermans, Tomahawks, and Havaharts are available to choose from depending on the size of the target species. Many papers have been written on the effectiveness and potential biases of many of these live traps (Grant 1970; Boonstra and Rodd 1982; Slade *et al*. 1993; O'Farrell *et al*. 1994). These studies should be consulted before a particular live trap is chosen.

Live capture of animals is not limited to box or cage-like traps. Depending on the species being targeted, an animal may be captured with snares (Lishak 1976), padded leg-hold traps, pitfalls, or mist nets.

There are numerous variations on the MRR method. However, all have common assumptions that must be met, or approximated, in order for subsequent data analysis and abundance estimates to be valid. These assumptions are:

1. Demographic and geographic closure (*i.e.,* the sample population is not significantly altered by births, deaths, immigration or emigration during the time of sampling).
2. All members of a population must have an equal or known probability of being captured (*i.e.,* Any sample should be representative of the population being sampled).

Only in rare situations are both of these assumptions ever met; however, it is important that continued efforts be made to approximate them, if accurate estimates of population size are to be attained. It is possible to minimize the effects of violating assumptions by modifying the general approaches discussed below. It can be useful to review some modifications to the basic formulas in literature such as Eberhardt (1969), Cormack (1972), O'Farrell *et al*. (1977), Pollock (1982), Krebs and Boonstra (1984), Nichols *et al*. (1984), Kenneth and Anderson (1985), Wilson and Anderson (1985), and Chao (1988). However, the computer program CAPTURE integrates all of these formulae into one comprehensive package, and researchers may find it easier to consult documents which deal with the suite of models used in CAPTURE, such as Otis *et al.* (1978), White *et al.* (1982), or Rexstat and Burnham (1991). See also the introductory manual, *Species Inventory Fundamentals, No. 1.*

Note: the assumptions of demographic and geographic closure are not needed if open Jolly-Seber mark-recapture models are to be used for analysis of the data. Also, the assumption of equal probability of capture can be relaxed if the closed models of program CAPTURE are used (see Data analysis section).

<u>Advantages:</u>

- Avoids wasteful killing;
- Can provide accurate estimates of animal abundance as well as other demographic parameters;
- Allows for insight into temporal data such as population trends;

- Should not disrupt the social organization of sampled population; and
- May be appropriate for sampling sensitive or rare species when kill trapping would not.

Disadvantages:

- Is more time demanding than other sampling techniques;
- Live traps are generally much more expensive than other sampling apparatus;
- More equipment required (handling bag, ear tags, tagging pliers, etc.) than with other sampling techniques;
- Difficult to meet assumptions of population closure and equal trappability;
- Personnel expertise required for species identification, handling, marking, etc.; and
- does not provide voucher specimens.

Office procedures

- Review the introductory manual *Species Inventory Fundamentals No. 1*.
- Obtain relevant maps of 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). Any map which is used to record data should be referenced to NAD83.
- Consult local experts and naturalists for suggestions.
- Select species to be surveyed and plan timing of surveys.
- Outline the Project Area on a map and 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.
- Select Study Areas based on existing data, personal experience, and topographic maps and that are likely to have suitable habitat.
- Locate capable Field Personnel.

Sampling design

Systematic layout

Sampling designs for MRR will vary with objectives of study. Traps are generally arranged systematically in a grid fashion. Dimensions of grids, and distance between trap stations are variables of considerable debate. These measurements should be based on the home range size used by each individual animal of interest. For example, if an animal has a home range of one hectare, it may not be necessary to have 10 traps per hectare, conversely it is likely not enough to have only one trap per two hectares. White *et al*. (1982) suggests that a trapping configuration that places four traps per average home range area be used. However, a problem arises when there are differences in home range sizes within a species (such may be the case between males, females, adults, and juveniles) and/or between species. The solution then becomes a compromise between the highest probability of capturing the desired species of animal(s) and the most efficient use of traps. Skalski and Robson (1992) have also provide methods, and limited results of optimal trap spacing to maximize catch per unit effort of traps.

In all cases, traps should be uniformly distributed across a study grid. Traps placed in a checkerboard fashion, or in unevenly spaced transects may create unequal capture probabilities and thus are not recommended. If the number of traps is limiting then it is better to increase trap spacing rather than space traps unevenly.

Commonly used trap spacings for sampling tree squirrels range from 15 to 60 m intervals (Sullivan 1990; Klenner and Krebs 1991; Dempsey and Keppie 1993; Sullivan and Klenner 1993). The trap layout most frequently found within the literature is a 9-ha grid design (30 m spacing, 16 x 6 rectangle or 10 x 10 square) with a single trap located at every other trap station. Boutin (pers. comm.), however, feels that a 9-ha grid is insufficient for accurately determining squirrel abundance. He suggests a trapping configuration that covers 40 ha with traps strategically placed at locations of active squirrel sign, such as middens. The standard method recommended for chipmunks, tree squirrels and flying squirrels, is a 9-ha grid design, a 16 x 6 rectangle or a 10 x 10 square, with 30 m between stations, and a trap placed at every other station.

The overall size of the study grid should be considered if estimation of density is an objective of the inventory effort. The size of grid areas will determine sample sizes in the mark-recapture data but will also influence the degree of edge area in the grid. If a grid is small compared to the home range area of a target species, an edge effect will be created, and density estimates will be positively biased. Given this, grid areas should be large compared to small mammal home range areas. Program CAPTURE has a nested subgrid algorithm that estimates the degree of edge area a grid might have. However, this routine needs very large sample sizes to give reasonable results. If a subsample of animals is radio collared and monitored during trapping then a correction factor can be calculated using the methods of Eberhardt (1990). More approximate methods for the estimation of the effective trapping area of grids are given by Bondrup-Nielsen (1983). These methods require knowledge of the home range size for the species. The general message is that most trapping grids in the past have been too small, and it is important to utilize as large a trapping grid as is required for the species involved.

Non-systematic layout

In some cases, a systematic trap layout is very inappropriate due to the specific habitat types used by some animals within our inventory group (*e.g.*, pikas, marmots, and ground squirrels that live in irregular, discrete talus patches). Smith (1982) reports that the uniform placement of trap grids is extremely ineffective for trapping pikas, and suggests that traps be placed only where pikas have been sighted or where there is sign. Many authors suggest that traps should be placed only at sites where active sign of squirrel, marmot, and/or ground squirrels exist (Armitage 1982; Balph 1982; Davis 1982a; Murie 1982; Zegers 1982; Price *et al*. 1986). The recommended method for marmots, ground squirrels and pikas is to have the investigator search the sample area for areas with active sign of habitation by these animals and then saturate these areas with live traps. The initial search allows the investigator to stratify the area, so that more of the sampling effort can be concentrated in high strata (where densities are expected to be greatest).

Because the areas in which marmots and pikas live are discrete, it is reasonable to assume that the effective trap area is the talus patch if a suitable number of traps are used for each animal inhabiting the talus patch. Fundamental to the success of live trapping pikas is the knowledge of talus areas inhabited by pikas (which can be obtained from relative abundance methods), proper placement of traps near hay pile or activity areas, and proper pre-baiting of traps with good native vegetation (J. Boulanger, unpublished data). In addition, mark-resight methods can be used with highly visible species such as pikas. When mark-resight methods are used the animals are initially trapped over a series of a few days. Visual markers such as thin telephone wire placed with wire eartags are put on individuals to allow visual identification. After the initial trapping period, observers resight individuals using a systematic sampling method, recording the color tag combination or the absence of tags if an animal is not marked. Potential sample biases such as unequal sightability, and emigration from the Study Area can be accounted for with this method. For this reason, the models of program NOREMARK should be used for analysis of the data (see *Species Inventory Fundamentals, No. 1*, Section 5.4).

Sampling effort

In most situations, one trap per capture station is usually sufficient. Within dense populations as many as three traps per capture station may be necessary to avoid trap saturation. However, such dense populations would be very rare with pikas and sciurids. Also, if sampling species of different sizes, traps of different sizes may be required if a representative sample is to be achieved.

Each period of sampling is referred to as a capture (trap) session. Unless trapping is performed continuously, capture sessions should be systematic in time. Monitoring intensity depends on the objectives of the study and often vary between trappers.

A common procedure for sampling Red Squirrels is a two-day capture session that is repeated every two to three weeks (Sullivan and Moses 1986). This design may work for population monitoring using the Jolly-Seber open model. However, it will not provide suitable data for use of the program CAPTURE models (see below).

The "robust" study design of Pollock (1990) is recommended if density estimates, and survival, and other demographic rates are an objective of inventory efforts. With this design, a series of five-day samples are conducted at equal intervals (*i.e.*, every month) during the time period of interest. The data from the five day sessions is used to estimate density using program CAPTURE. (See section on data analysis, and *Species Inventory Fundamentals, No. 1*, appendix G for more details on program CAPTURE.) In addition, these data are pooled and used with the Jolly-Seber model to estimate survival and other demographic parameters (using JOLLY or JOLLYAGE). This design has the following advantages:

1. Theoretically robust estimates of population size and survival are possible

2. Temporary emigration from the Study Area can be estimated from the data set allowing for further demographic inference, and less biased survival estimates if a subset of the population is not available for capture in a given trapping period. A new program, RDSURVIV, has been designed for this purpose when the robust design is used (see *Species Inventory Fundamentals, No. 1*, appendix G).

3. The data should also allow further demographic inference and model fitting of survival rates using programs MARK, SURGE, and POPAN (see *Species Inventory Fundamentals, No. 1*, appendix G).

Note that Pollock's (1991) robust design is similar to the Sullivan and Moses's (1986) design except that there are four to five day capture (sample) sessions instead of two day capture session. Note that four to five continuous days of trapping may be detrimental to many small mammals if each animal is caught many times. It may be necessary to have a break of one or two days in the middle of a five day session to give the animals some time to recover from the stresses of being in live traps.

Methods are available for biologists to determine appropriate sample sizes for the various mark-recapture estimators. It is recommended that project biologists consult the following sources for sample size calculations (Table 3).

Table 6. Sources for sample size calculation

Estimator	Source for optimal sample size calculation:
Lincoln-Peterson estimator.	Krebs (1989 page 22)
Jolly Seber estimates	Pollock (1990, page 72) Simulation: POPAN (Arnanson and Schwarz, 1987)
CAPTURE	White *et al*. (1985) Simulation: CAPTURE

The above references include graphs, and discussions of needed sample sizes for estimators. The determination of optimal sample sizes for program CAPTURE is complex. An easy to use simulation module is available as part of program CAPTURE to allow biologists to explore sample size issues.

Time requirements

The time required for an MRR program depends on the objectives of the inventory. Some methods of data analysis require only two capture sessions (the first to mark a portion of the population, the second to determine a ratio of marked to un-marked animals) while other methods require numerous capture sessions at regular intervals throughout a sampling period. Regardless of the number of capture sessions to be performed, individual sessions should be very similar.

Note that there are many variables that affect the number of traps that can be successfully trapped by one person. Some of these variables are:

- Species being trapped (*e.g.*, a marmot will take much longer to handle and tag than a chipmunk);
- Numbers of animals (*i.e.*, a large number of animals will take longer to handle and mark than a small number of animals);
- Distance between trapping stations;
- Difficulty of travel between capture stations; and
- Experience of personnel.

Personnel

- Must understand the proper operations of the traps used for sampling to ensure that they are set and baited for the best results.
- Must be able to identify the animal to the species level in the hand. Field guides and instructions from experts will aid in the identification of ambiguous species.
- Must be trained as to the correct procedure of handling and marking animals in a way that is least stressful for the animal. Anyone handling live wild animals should be thoroughly familiar with CBCB manual No. 3, *Live Capture and Handling of Wild Mammals, Birds, Amphibians and Reptiles*. As well, completion of a course in chemical immobilization of wildlife is mandatory before using means of chemical restraint (if required).

Equipment

- Traps

Tomahawk Live Traps
Tomahawk Live Trap Company
Tomahawk, Wisconsin
Tel. (715) 453-3550

Sherman Traps
H. B. Sherman Traps, Inc.
Tallahassee, Florida
Tel. (904) 562-5566

Havahart Live Traps
Ekco Canada
Niagara Falls, Ontario
Tel. (905) 357-3440
Fax (905) 357-3445

Bolton Live Trap
B. N. Bolton, Inc.
Vernon, B.C.
Tel. (604) 545-9171
Fax (604) 545-4433

Longworth Live Trap
Longworth Scientific Instrument Co., Ltd.

- Bait
- Bedding (if overnight trapping)
- Water-proof data book
- Tags
- Tagging pliers
- Handling glove
- Weigh scale
- Handling bag
- General outdoor attire, such as raingear, boots, etcetera.

Field procedures

First capture session *(see below for detailed descriptions of each step)*

- Set traps with bait at capture stations
- Check traps (twice or more per day)
  - Mark and measure unmarked animals
  - Record data
  - Release trapped animals
- Repeat procedure for length of capture session. Remember that it may reduce stress on the focal population to allow for a break between successive nights of capture.

Subsequent capture sessions *(should be systematic in time)*

- For recapture surveys, repeat as above but do not mark unmarked animals.
- For resight surveys (maybe used for pikas), observers resight animals using a systematic sampling method, recording individuals by their color tag combination or absence of tags if not marked.

Trap placement

- A prebait (a pre-sampling period of baited traps set in such a way as to allow the animal in the trap without being captured; door locked open) is highly recommended to allow the animals to habituate to the presence of the traps. A prebaiting period will significantly improve trap success.
- Lay out grids and discrete areas for sampling, marking capture stations with flagging.
- For systematic grids of live traps sampling design, live traps, including box traps (Shermans and Longworths) and cage traps (Tomahawks and Havaharts), should be placed within a 2-m radius of a given capture station. Within that 2-m radius, it is preferred that the traps be placed within a strategic location, such as along an active runway or near a burrow, to maximize the probability of capture.
- For non-systematic trap sampling designs used in discrete areas (*e.g.*, a talus patch), place a suitable number of traps for the number of animals expected near hay piles or activity areas.
- Traps should either be placed under natural cover (a log, thick brush, etc.) or should be covered with a square (30 x 30 cm) piece of plywood or shingle (for smaller box traps), or by roofing paper folded lengthwise over the top and two sides of larger cage traps. This cover shades the animals from direct sunlight and shelters them from rain, thereby reducing animal stress and possible trap mortalities.
- Traps should be placed in a stable manner to prevent an animal from being scared away from a trap that rocks or wobbles when it is stepped in. Smith (1982) suggests stabilizing wobbly traps by placing a rock on top of them.
- Care needs to be taken to insure that there are no obstructions, such as branches or leaves, that might hinder the trap door from closing. In addition, with gravity-fed doors, as with the Longworth trap, a level or downhill orientation is required to facilitate closing of the trap door.

Setting traps

- Set traps early in the morning. It is especially important that traps be set as early as possible when expected daytime temperatures are going to be >25^{o}C.

  Note: If daytime temperatures are going to be >25^{O}C, traps should be adjusted so that an animal can not be trapped during the hot hours of midday. This can be accomplished by closing the trap door, setting the trap on end, or locking the trap door open. These measures are required to avoid trap mortalities caused by hyperthermia, as animals are not able to effectively thermoregulate while inside a trap. Traps can again be set for trapping after the heat of midday has passed.
- In most cases, setting the trap simply implies baiting it with the appropriate food source (see below) and adjusting the trap so that it will capture a visiting animal. These adjustments usually involve manually setting off the trap a few times to insure that the trap door successfully closes upon tripping the treadle mechanism (*i.e.*, ensure that the treadle is not jammed and that the trap door is free to close).
- Provide dry bedding material, such as coarse brown cotton if overnight trapping. Bedding material, placed within a nest box, is required to decrease trap mortality when live trapping Northern Flying Squirrels (*Glaucomys sabrinus*) as this squirrel often spends the night in the trap. Overnight trapping should not be done without bedding material.

Baiting traps

Bait has two purposes in live trapping: 1) it sustains the animal while captive in the trap, and 2) may serve as an attractant for the animals, thereby increasing the probability of capture. Types of bait used will largely depend on the species being trapped. Below are some examples of baits used for various animals.

- Tree squirrels: Sullivan (1990) recommends about 10 g of sunflower seed with a slice of apple for Red Squirrels and Douglas' Squirrels (Sullivan and Sullivan 1982). Dubock (1982) recommends maize or other grain (soaked for 12 h in water if trapping in dry and hot weather) as bait for Gray Squirrels. Because the nocturnal, Northern Flying Squirrel is normally trapped overnight and spends a rather long time in a cold trap, protein rich bait seems to be necessary to reduce the often high rates of trap mortality. Ransome (pers. comm.) recommends a high protein mixture of rolled oats and peanut butter be used.
- Chipmunks: Can be sustained within Longworth live traps on whole oats and a slice of carrot for moisture (Sullivan, pers. comm.). Yahner (1982) and Sullivan and Klenner (1993) also report that cage traps can be used when baited with sunflower seeds or a peanut butter/oat mixture.
- Ground squirrels: Bacon, oats, lettuce, carrots, peanut butter, and apples have all proved to be successful baits for ground squirrels (Balph 1982; Murie 1982; Zegers 1982).
- Marmots: Davis (1982*a*) uses apples as bait for Woodchucks (*Marmota monax*). Armitage (1982) suggests that salted oats work best, but any grain or horse feed can be used. Bryant (pers. comm.) has had success using peanut butter as bait for Vancouver Island marmots.
- Pikas: Smith (1982) suggests using fresh local vegetation as a bait for pikas, but reports that fruit, such as apple, works too.

Checking traps

- Traps should be checked at least twice during the day (once in the early afternoon and again before dark) or more frequently if it will avoid trap mortalities.

Handling animals

The method of handling animals depends primarily on which species is trapped. The method of choice should minimize the animal's level of stress. Below are some examples of handling methods used by various experts. Literature and/or experts may be consulted for a more detailed description of handling.

- Tree squirrels-A common method of handling these lightning fast creatures involves transferring them from the trap to some sort of holding apparatus. Sullivan (pers. comm.) prefers a heavy duty, clear plastic bag with tiny holes in one corner to facilitate ear tagging. Others recommend the use of a conical net bag for handling Red Squirrels (Klenner and Krebs 1991) and Northern Flying Squirrels (Ransome 1994). Perry (1982) recommends the use of a burlap or muslin sack while Dubock (1982) suggests a handling cylinder made out of weld-mesh.

  Note: Regardless of which method is used, care must be taken not to grasp the squirrel by the tail as the skin will easily separate from the tail vertebrae. The resulting wound may lead to infection and possible death of the squirrel.
- Chipmunks: Can be handled with a gloved hand or, like squirrels, within a handling bag (Yahner 1982). Again, care needs to be taken not to handle the chipmunk by the tail (see tree squirrels).
- Ground squirrels**:** Balph (1982), Murie (1982), and Zegers (1982), all report that ground squirrels can be successfully handled with a gloved hand. The squirrel can either be grabbed directly from a trap or from a holding bag. The squirrel can also be worked on within a holding bag as with tree squirrels.

- Marmots: Davis (1982*a*) and Armitage (1982) both suggest that this large squirrel be transferred into a holding net or conical bag for handling.
- Pikas: Smith (1982) states that pikas can be handled in a holding similar to that used with chipmunks and tree squirrels. However, he suggests that the use of an anaesthetic, such as Metofane®, makes the handling process easier, and reduces the risk of animal dying in hand from rabbit-shock-disease.

Marking Animals

There are two categories of markings that are commonly applied to animals during MRR sampling; inconspicuous and conspicuous markings.

- Inconspicuous markings are designed for individual identification of animals in the hand. The use of numbered ear tags is the only acceptable method recommended for inconspicuous marking at this time. Tags should be placed low in the ear (where the cartilage is the thickest), and within the inner edge of the ear (for protection) to reduce the risk of the tag being ripped out (Call 1986). Placing one tag per ear also reduces the risk of losing the identity of an individual by tag loss. [For smaller animals and/or juveniles, toe clipping is reported as a means of permanent marking (Day *et al*. 1980; Davis 1982*b*). However, toe clipping is strongly discouraged, as it mutilates the animal and is considered *unacceptable* method by certain Animal Care Agencies. In addition, toe clipping may have a significant effect on the survival of the marked animals (Pavone and Boonstra 1985).]
- Conspicuous markings are designed to allow for individual identification of animals from a distance. Conspicuous markings include large coloured ear tags, coloured ribbons (yarn, flagging tape, etc.) tied to less conspicuous ear tags, and pelage colouring. Commercial fur dye or hair dye makes an effective marking, however, it will only last until the animal's next moult.

Recording data

Once the animal has been restrained, in the hand or in a holding bag, record the following information:

1. Species (see CBCB manual No. 2 for standard species codes that should be used when recording data)
2. Identification marking (ear tag number, pelage marking, etc.)
3. Point of capture (capture station)
4. Sex
    - Sciurids are relatively straightforward to differentiate as sexual dimorphism exists; however, juveniles may be challenging to sex.
    - Pikas can be quite difficult to sex as little sexual dimorphism exists; see Smith and Weston (1990) for details.
5. Weight. Hand-held spring scales are recommended
6. Reproductive condition
    - Scuirids
        - Male: Palpate the testes to determine whether scrotal or abdominal
        - Female: Observing the condition of mammaries to determine whether lactating or not
    - Pikas - difficult to determine reproductive condition
        - All males have abdominal testes
        - Females have very inconspicuous mammaries
        - see Smith and Weston (1990) for more details

Data analysis

The project biologist should be familiar with the different methods of data analysis for mark-recapture inventories before data collection begins. Different assumptions and requirements of the various models will have great bearing on sample design, effort and overall approach.

Below is a cursory discussion of mark-recapture models. This is included to provide biologists with an overview; however, a greater depth of knowledge will be required to actually carry out a mark-recapture inventory. Prior to commencing, it will be necessary to consult *Species Inventory Fundamentals No. 1* as this manual provides descriptions of many techniques which are generic to species inventory. In addition, the following is a short list of some useful texts and articles. For complete citations see Literature Cited.

1. White *et al.* 1982. In some opinions, this is by far the most readable reference on mark-recapture that is available. Available at:

   http://www.cnr.colostate.edu/~gwhite/software.html
2. Buckland *et al.* 1993. Good text for distance and transect sampling.
3. Krebs 1989, (also 1998, 2nd Edition). Good all round discussion of study design, but Chapter 2, Estimating abundance: Mark-and-Recapture techniques, is especially appropriate).
4. Pollock *et al.* 1990. A good discussion of the Jolly-Seber model.
5. White and Garrot 1990. A good discussion of study design for radio-telemetry estimation studies.
6. White 1996. A good discussion of mark-resight estimation procedure.
7. Schemnitz 1980*. Wildlife management techniques manual* (especially chapter 14 - Estimating the numbers of wildlife populations. pages 221-246).

There are numerous ways of analyzing data from a MRR program. The level of confidence placed in any estimator is largely dependent upon sample size, sample effort and how well the assumptions of the analysis methods are met in the field. Some common methods of analyses found in the literature are summarized below to provide some background information. Many sophisticated and robust methods of analyzing MRR data are available as part of the programs CAPTURE, JOLLY and MARK; all of these are discussed in *Species Inventory Fundamentals*.

Minimum-Number-Alive Estimator (MNA)

One of the easiest ways of estimating the abundance of a population from a mark-release-recapture (MRR) program is called the minimum number alive method (MNA). MNA (also called the calendar count or enumeration) is an estimate based on the sum of all individuals known to be alive during a particular capture (trapping) session. An individual is known to be alive during a given capture session if it was captured during that session, or if it was captured before and after that capture session. For example, if an individual is captured during capture session #1 and #3, it can be accurately stated that it was missed (but alive) during session #2.

Although the MNA method is simple to use, this estimator has been criticized as being negatively biased in most situations. For this reason, in a summary, Ritchie and Sullivan (1989) suggest that the MNA estimate should only be used when the trappability of animals is >70%. Several articles have been written on the use of the MNA estimator (Hilborn *et al.* 1976; Jolly and Dickson 1983; Nichols and Pollock 1983; Boonstra 1985; Efford 1992; Hilborn and Krebs 1992). Most of these papers recommend the use of the Jolly-Seber estimator over MNA if trappability is low or unknown.

This approach, also referred to as “saturation trapping” or “enumeration” is generally not the best means of achieving a statistically valid estimate, and is not recommended. The reasons for this are:

- In many cases, a large amount of effort is needed to fully trap a population. In contrast, a valid estimate of population can be gained with less effort by using a ratio estimator, or a closed CAPTURE mark-recapture estimator.
- The assumption that an entire population is trapped or marked can not be validated and therefore population estimates can be negatively biased (Pollock *et al.* 1990).
- To get an unbiased estimate of density, a population should be geographically closed. To minimize violation of this assumption, sampling should occur in a relatively small amount of time. Saturation trapping usually takes long periods of time, and therefore closure assumptions will be violated unless the researcher is working on an entirely closed system, such as an island.

Estimation by Asymptotic Capture

Population abundance can be estimated by intensively trapping and marking a population until no new (unmarked) individuals are captured. This method is essentially a modified (*i.e.*, non-lethal) version of kill trapping where animals are removed until no animals remain. It is generally not recommended as it is subject to criticisms similar to those described above.

Ratio estimators

The Lincoln, Petersen, and Schnabel estimators are based on the ratio of marked to unmarked individuals within a population. These estimators assume that the population is “closed” to immigration and emigration. The formulas are based on the assumption that the population size is related to the number of marked and released animals in the same way that the total caught at a subsequent time is related to the number recaptured (Davis and Winstead 1980). White *et al.* (1982) offer excellent discussion of closed models which many be calculated using the program CAPTURE.

The Petersen (or Lincoln-Petersen) estimate is the most basic MRR method. It is based on two sample periods only (*i.e.*, one period of marking animals, followed by a single period of recapture). It is described using the following formulas:

$$\frac{N}{M} = \frac{C}{R} \tag{1}$$

therefore:

$$N = \frac{CM}{R} \tag{2}$$

where:

N = Population Estimate

M = Number of marked and released animals

C = Total number of animals captured

R = Number of marked animals that were recaptured

Lincoln-Peterson estimates are easy to calculate, and the estimator has been shown to be robust to time variation in capture probabilities. However, there are important assumptions associated with this estimator such as equal probabilities of capture between animals, population closure, and no net loss of animal marks between samples. If relative abundance is the objective then violations of assumptions may not be as significant provided that the degree to which assumptions are violated is similar between studies and over time, and therefore the estimator will show a consistent, comparable bias. If absolute abundance is the objective of methods, and animals can be marked individually then the use of the estimators in program CAPTURE is recommended.

Numerous variations on the Petersen Estimate have been developed. The Petersen Estimate is biased in that it tends to overestimate the actual population, especially if the sample is small. In response to this bias, Seber (1982) offers a variation on Petersen's formula that is less biased, and nearly unbiased if there are at least seven recaptures of marked animals. Another variation, the Schnabel estimate was developed to allow investigators to analyze data from multiple (>2) marking sessions.

The Jolly-Seber Estimator

Like the Lincoln, Petersen, and Schnabel estimators (above), the Jolly-Seber estimator is also based on the ratio of marked to unmarked individuals within a population. However, the Jolly-Seber estimate differs from others in that it recognizes, and attempts to incorporate, the fact that biological populations are generally not "closed". This "open" model will not provide a true estimate of density, but rather of abundance, as the population is not defined in terms of area. This estimator requires that *at least three* sampling periods be carried out in order to calculate certain variables. Pollock *et al.* provide good discussion of Jolly-Seber models, and the program JOLLY is very useful for simulating MRR or analyzing data.

The formula for the Jolly-Seber estimate of population size is given below.

$$N_t = \frac{M_t}{\alpha_t} \tag{3}$$

where:

N_t = Population estimate just before sample t

t = Sample period (1,2,3,4,5,......t th sample)

α_t = proportion of animals marked

$$\alpha_t = \frac{m_t + 1}{n_t + 1} \tag{4}$$

m_t = Number of marked animals that were recaptured during sample t

n_t = Total number of animals captured during sample t

M_t = Estimated number of marked animals just before sample t

$$M_t = \frac{(s_t + 1)Z_t}{R_t + 1} + m_t \tag{5}$$

s_t = Number of animals released

s_t = (n_t - accidental deaths)

R_t = Number of animals released during sample t, or s_t that were recaptured during a later sampling period

Z_t = Number of animals that were not captured during sample t, but were captured before and after sample t

The Jolly Seber model is also susceptible to biases if unequal capture probabilities are exhibited in the trapped population; however, the survival rate estimate of the Jolly Seber is robust to most forms of capture probability variation, and is therefore a useful alternative for monitoring populations. In addition, there are many modifications to the Jolly-Seber to accommodate age-specific capture probabilities and survival rates (program JOLLY JOLLYAGE and POPAN). If the robust design is used then program RDSURVIV can be used to estimate temporary emigration, and allow more precise survival estimates. Also, the Jolly Seber approach to survival modeling has been modified to allow the testing of biological hypothesis using various model fitting procedures as documented in programs SURGE, and MARK. However, many of the programs mentioned (with the exception of JOLLY and JOLLYAGE) require advanced statistical knowledge, and project biologists are urged to seek the advice of a qualified biometrician. A summary of useful software is available in *Species Inventory Fundamentals, no. 1*, appendix G.

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.

ASYMPTOTE: Mathematically, an asymptote is a value that is approached, but never quite reached, by observed values. Graphically, an asymptote appears as a "levelling off" of observations.

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, DC. 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.

CACHE: A storage, usually of food for the winter months.

CAPROPHAGY: Caprophagy is the reingestion of soft feces in order to capture vitamins that would otherwise be wasted.

CBCB (Components of BC’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.

CENSUS: A census is a count of a given species for a given area. Because an actual count of wild animals is rarely possible some sort of sampling design is often employed in order to estimate a census.

CONCEPTION: Fertilization of an egg by a sperm.

CONSPECIFIC: Conspecifics are animals that belong to the same species.

COPULATION: Sexual intercourse.

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 daylight hours.

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 BC’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.

FOSSORIAL: Adapted for living below the ground.

GESTATION PERIOD: Time required for the development of a healthy fetus (*i.e.*, time period from fertilization to birth).

HERBIVORE: Adapted for eating plant matter only.

HIBERNACULUM: Place where a hibernating animal resides during hibernation.

HIBERNATION: A period of dormancy (lowering of metabolic rate so as to reduce energetic demands for survival) assumed by some animals during periods of unfavourable climatic conditions.

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.

LAGOMORPH: A member of the order of pikas, rabbits, and hares.

MIDDEN: Storage pile of conifer cones for consumption during the winter months.

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

MONOESTRUS: Having a single breeding season each year.

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.

OMNIVORE: Having an unrestricted diet (*i.e.*, will consume both plant and animal matter).

POLYOESTRUS: Having more than one breeding season per year.

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 BC 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/]

SCIURID: A member of the order of squirrels; includes tree squirrels, flying squirrels, ground squirrels, chipmunks, and marmots.

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.

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.

TORPOR: A state of inactivity.

TRAP SATURATION: A situation when all (or nearly so) traps are occupied by a captured animal during a single sample.

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

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