Inventory for Hares and Cottontails

Standards for Components of British Columbia's Biodiversity No. 23

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Ministry of Environment, Lands and Parks
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Preface

This manual presents standard methods for inventory of hares and cottontails 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 either of these activities.

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

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

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

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 are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this document are based on the unpublished draft manual, *An Inventory Manual For Hares and Cottontails in British Columbia*, prepared for the Resources Inventory Committee by Mark A. Fraker and William J. Gazey with editorial assistance by Tom Ethier and Ann Eriksson. A number of people generously shared information for the draft manual, and they include Charles Krebs, Donald Doyle, Frederick Knowlton, Joseph Chapman, Robert Forbes, David Nagorsen, Thomas P. Sullivan, William R. Edwards, and Wayne C. Webber.

The Standards for Components of British Columbia’s Biodiversity series is currently edited by James Quayle with data form development by Leah Westereng.

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1. INTRODUCTION

This manual provides background information and standard protocols for the inventory of hare and cottontail populations in British Columbia. Three levels of inventory are considered: presence/not detected, relative abundance, and absolute abundance.

The mammal fauna of British Columbia in the 20th century has included five species of hare and cottontail, three native: Snowshoe Hare, Nuttall's Cottontail, and Eastern Cottontail, and and two introduced: European Rabbit and White-tailed Jackrabbit, (Cowan and Guiget 1965).

The emphasis in this manual is on the first three species. The White-tailed Jackrabbit is apparently extirpated in B.C., while the European Rabbit is not well established.

2. INVENTORY GROUP

The following is a list of leporids found in British Columbia:

Order Lagomorpha

Family Leporidae

Snowshoe Hare[1] *(Lepus americanus)*

Nuttall's Cottontail[2] *(Sylvilagus nuttallii)*

Eastern Cottontail *(Sylvilagus floridanus)*

European Rabbit *(Oryctolagus cuniculus)*

White-tailed Jackrabbit *(Lepus townsendii)*

Status: The Snowshoe Hare subspecies *L. americanus washingtonii* and the White-tailed Jackrabbit are on the provincial red list, Nuttall's Cottontail is on the blue list, and all other species are on the yellow list (1996).

2.1 Snowshoe Hare *Lepus americanus*

The Snowshoe Hare is widespread throughout the province, except for Vancouver Island, the Queen Charlotte Islands, and coastal islands (Cowan and Guiget 1965). It is well known that Snowshoe Hare populations cycle in size over a 9-11 year period over much of the northern portion of its range; fluctuations exceeding 100-fold have been reported (Krebs *et al.* 1986). However, populations in the southern parts of its range in western North America do not undergo large changes (Wolff 1982). The magnitude of these fluctuations has obvious implications for comparing densities between areas in different years or where cycles may be "out of phase". Even detection of hares within areas where they are sometimes abundant may be difficult during population lows.

2.2 Nuttall’s Cottontail *Sylvilagus nuttallii*

Nuttall's Cottontail has expanded its range into the southern Okanagan and Similkameen valleys from adjacent Washington state in this century (Cowan and Hatter 1940), and it has continued to expand its range, albeit very slowly (Sullivan *et al.* 1989; Carter *et al.* 1993). Sullivan *et al.* found Nuttall's Cottontails primarily in sagebrush-dominated and orchard / old field habitats. Southern B.C. is the northernmost part of the range for the subspecies,

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[1] may be referred to as Varying Hare in some references

[2] may be referred to as Mountain Cottontail in some references

Sylvilagus nuttallii nuttallii; another subspecies, *S. n. grangeri,* occurs well into the southern parts of Alberta and Saskatchewan (Chapman and Ceballos 1990).

2.3 Eastern Cottontail *Sylvilagus floridanus*

The Eastern Cottontail has expanded its range into the Lower Mainland from introduced populations in Washington State (Cowan and Guiget 1965). *Sylvilagus floridanus alacer,* originally native to Texas, Oklahoma, Missouri, Arkansas, and Louisiana, was introduced into western Washington in 1927 and 1931 (Nagorsen 1990). Forbes (pers. comm.) reports that cottontails are common in the Lower Fraser Valley along dikes and in agricultural areas from Tsawassen to Chilliwack. *S. f. mearnsi,* native to southern Quebec, Ontario, and eastern and north-central United States, became established on southern Vancouver Island from a release near Sooke in 1964 (Nagorsen 1990). Since then it has spread northward along the eastern side of Vancouver Island. Presently the Eastern Cottontail is common as far north as Campbell River, and some are present as far as Sayward (Doyle, pers. comm.).

2.4 European Rabbit *Oryctolagus cuniculus*

The European Rabbit has escaped or has been introduced into several places in southwestern B.C., Vancouver Island, and some other islands. While this species has become well established and very abundant on San Juan Island and other islands in the San Juan Archipelago in Washington state (Stevens and Weisbrod 1981), it has not done nearly so well in the southern Gulf Islands. Although Nagorsen (1990) says that populations are established on Sidney, James, and Triangle islands, an extensive search by the author and interviews with workers on Sidney Island failed to find any recent sightings, and it appears that the species is no longer present there. Nagorsen (1990) also states that small localized populations may exist on Vancouver Island and the mainland.

2.5 White-tailed Jackrabbit *Lepus townsendii*

The range of the White-tailed Jackrabbit formerly extended northward into the southern Okanagan Valley. In the course of a study of Nuttall's Cottontail in the southern Okanagan and Similkameen valleys, Sullivan *et al.* (1989) failed to detect the presence of White-tailed Jackrabbits during their three seasons of research. Carter and Harestad (1991) conducted field surveys and interviews with knowledgeable persons and could find no evidence confirming the presence of White-tailed Jackrabbits in B.C. during the preceding decade. They also noted that the White-tailed Jackrabbit in B.C. was at the northern extremity of the western part of its range, and that the species had declined in abundance in Washington state, particularly in the north. Carter and Harestad (1991) believe that the White-tailed Jackrabbit in B.C. should be considered extirpated.

3. PROTOCOLS

Table 1 summarizes the recommended methods for inventory of hares and cottontails in British Columbia. Detailed protocols for each method are outlined in following sections.

Table 1. Recommended inventory methods for hares and cottontails in British Columbia at 3 levels of intensity.

Species	Recommended Methods		
	Presence/Not Detected	**Relative Abundance**	**Absolute Abundance**
Snowshoe Hare & Nuttall's Cottontail	Detection Transect Survey	Pellet Counts	Mark-Recapture
Eastern Cottontail	Roadside Surveys	Roadside Surveys	Mark-Recapture

3.1 Sampling Standards

The following standards are recommended to ensure comparison of data between surveys, and to mitigate several sources of bias common in surveys. Individual protocols provide more detailed standards applicable to the method(s) and design recommended.

3.1.1 Habitat Data Standards

A minimum amount of habitat data must be collected for each survey type. The type and amount of data collected will depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory. As most, provincially-funded wildlife inventory projects deal with terrestrially-based wildlife, the terrestrial Ecosystem Field Form developed jointly by MOF and MELP (1995) will be used. However, under certain circumstances, this may be inappropriate and other RIC-approved standards for ecosystem description may be used. For a generic but useful description of approaches to habitat data collection in association with wildlife inventory, consult in the introductory manual, *Species Inventory Fundamentals* (*No.1).*

3.1.2 Timing of Surveys

The following biological factors should be taken into considerations when planning the timing of inventory surveys for leporids in British Columbia.

Population dynamics

Populations of rabbits and hares show both seasonal and annual changes in density. Densities are highest at the end of the breeding season and lowest at the end of winter (Lord 1961).

Snowshoe Hares are famous for undergoing large changes in population size. Krebs *et al.* (1986) demonstrated a change of 141-fold in spring numbers and a 268-fold change in August numbers from 1976-1984 in their southern Yukon study area. While population cycles tend to be synchronous over large areas, local populations can be "out-of-phase". Populations in the southern part of the Snowshoe Hare range in western North America do not cycle (Wolff 1982).

Home range size

Harestad and Bunnell (1979) collated information on home range size for a large number of species, including the Eastern Cottontail and Snowshoe Hare. They report mean home range sizes of 1.62 ha and 5.93 ha for Eastern Cottontails and Snowshoe Hares, respectively.

Krebs *et al.* (1986) found an average home range size of 4.9 ha for Snowshoe Hares in the southern Yukon.

Dixon *et al.* (1981) studied winter home range size of Eastern Cottontails in an agricultural area of southwestern Wisconsin using radio telemetry. They found that the mean home range size was 3.01±0.25 ha. Jurewicz *et al.* (1981) studied the home range size and spatial relationships of female cottontails in the same area where Dixon *et al.* (1981) did their work. They found that during the period 15 April to 31 May, the mean nocturnal and diurnal home ranges were 0.7 and 2.5 ha. During the period 1 June to 9 August, the figures were 1.2 and 3.7 ha. The increase in home range size occurred as agricultural crops grew and provided both food and cover, and the cottontails ventured away from their "bases" in a woodlot.

3.1.3 Survey Design Hierarchy

Hare and cottontail surveys follow a sample design hierarchy which is structured similarly to all RIC standards for species inventory. Figure 3 clarifies certain terminology used within this manual (also found in the glossary), and illustrates the appropriate conceptual framework for a pellet count survey for hares and cottontails. A survey set up following this design will lend itself well to standard methods and RIC data forms.

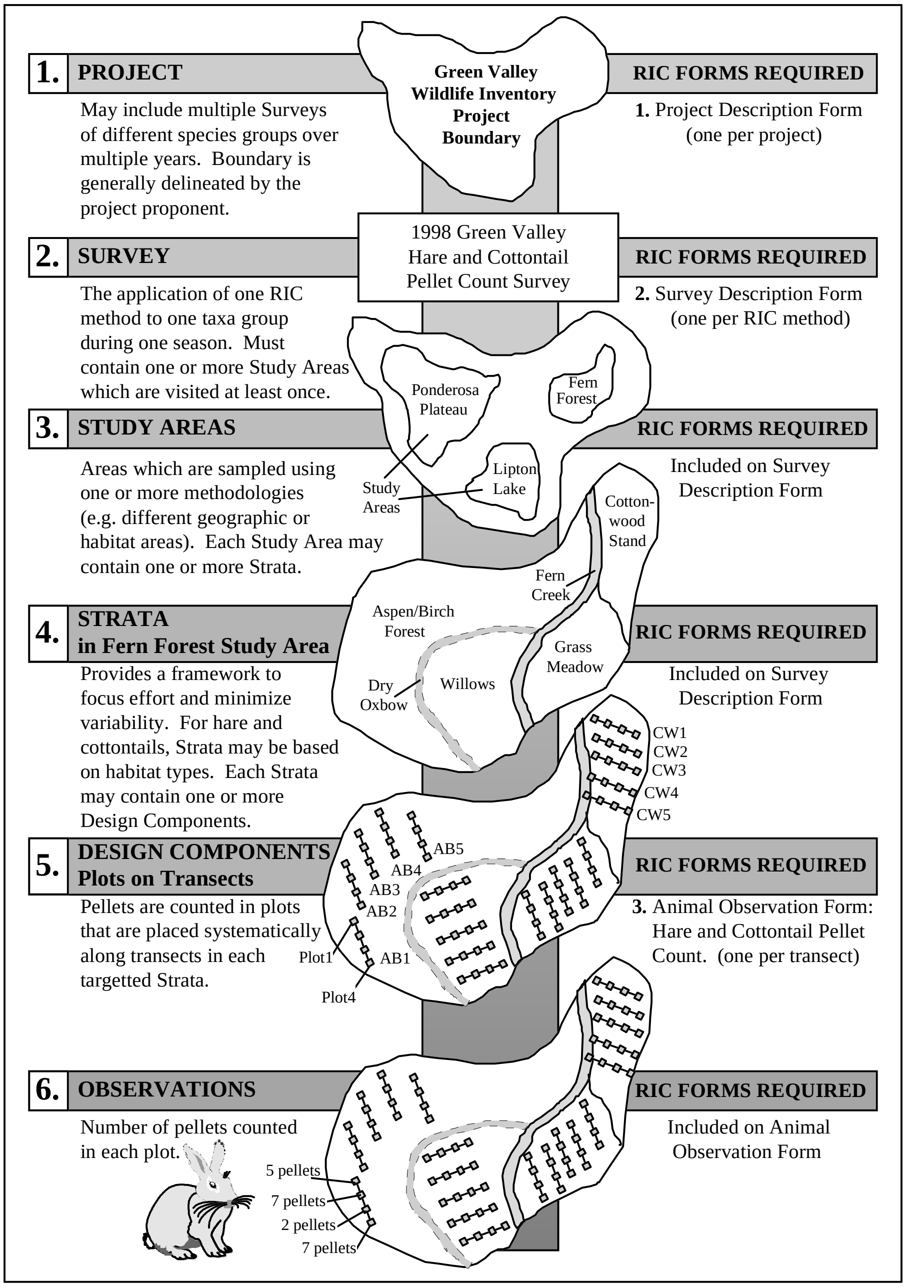

Figure 1. RIC species inventory survey design hierachy with examples.

3.2 Inventory Surveys

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

Table 2. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Type	Forms Needed	*Intensity
Detection Transect	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form - Hare & Cottontail - Transect	• PN
Roadside	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form - Hare & Cottontail - Transect	• PN • RA
Pellet Count	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observation Form- Hare & Cottontail - Pellet Count • Ecosystem Field Form	• RA
Mark-Resight	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Capture (Station) Form- Hare & Cottontail Capture • Animal Observation Form- Capture - Hare & Cottontail • Ecosystem Field Form	• AA

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

3.3 Presence/Not Detected

Recommended method(s): Detection transects for Snowshoe Hares and Nuttall's Cottontail; Roadside surveys for Eastern Cottontails.

3.3.1 Detection Transect (Snowshoe Hare & Nuttall's Cottontail)

As a standard field technique, applicable to all leporids anywhere in the province, a systematic detection transect for sign of cottontails or hares in appropriate habitats is recommended.

Chapman and Willner (1986) state that the presence of cottontails and hares can be determined by "activity signs"(*i.e*., fecal pellets, tracks, active runways and trails, feeding sites, and skeletal remains). Since there is relatively little overlap of the ranges of cottontails and hares in B.C., sign of leporids could usually be assigned to a particular species with a reasonable degree of certainty.

Wolfe *et al.* (1982) used the presence of fecal pellets to determine the use of different montane vegetation types by Snowshoe Hares in northern Utah. They used 5 pairs of circular 1.8 m^2 (0.75 m radius) plots placed at 15-m intervals in each of four habitat types. They used the fecal pellet counts to determine both presence/not detected and relative use.

Sullivan *et al.* (1989) estimated the use of various habitat types by Nuttall's Cottontail by a modification of methods used by Wolfe *et al.* (1982). They established pairs of permanent 1.8 m^2 (0.75 m radius) plots along transects, each with 10 stations spaced 30 m apart.

Where hares browse woody vegetation, it is possible to determine their presence because of the distinctive "clean, chisel-cuts" that they leave on the browsed stem; ungulates leave "ragged" edges on browsed stems (Krebs, pers. comm.; Sullivan 1990). By assessing the age of new growth since the plants in an area were heavily browsed by Snowshoe Hares, it is possible to determine the last period of peak abundance.

Sullivan and Sullivan (1983) showed that there was an increase in both the number of wounds and the percentage of Lodgepole Pine *(Pinus contorta)* trees damaged as the estimated density of Snowshoe Hares increased. Snowshoe Hares eat the bark, cambium, and outer vascular tissue of trees. Red Squirrels *(Tamiasciurus hudsonicus)* leave similar scars, but they strip away the bark and discard it (Sullivan and Sullivan 1982; Sullivan 1990).

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- It is recommended to use information from biologists, trappers, residents, and other knowledgeable persons as a first approach to determine whether the species of interest is thought to be present in an area. A field survey is then conducted to confirm its presence in a given area.
- Obtain relevant maps for project and study area(s) (*e.g.,* 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). At minimum, a 1:50 000 map of region is needed so that study area(s) can be delineated.

- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the project area from maps.
- Select study areas from maps that are likely to have suitable hare or cottontail habitat. Do this by stratifying the project area by habitat or based on expected densities.

Sampling Design

- Systematic sampling along transects. May first stratify for particular vegetation or habitat types.
- This survey is aimed at finding fecal pellets in plots laid out systematically along transect lines. Because a detection survey should make use of whatever positive information is available, one should search for any sort of sign along the transect (*i.e,*. pellets, tracks, active runways and trails, feeding sites, and skeletal remains).

Sampling Effort

- A minimum of 5 transects in each of the habitat types or areas to be surveyed is recommended.
- If the only aim is to detect the presence of a species in an area, and if the species is detected while sampling an early transect, there would be no need to run all transects.

Survey Timing

- Surveys can be conducted at any time when the ground is clear of snow.

Personnel

- Transects can be run by one or two persons with a minimal amount of equipment.
- Personnel should be trained to identify animal sign and the means of distinguishing between browsing sign of hares and other herbivores (Sullivan and Sullivan 1982; Sullivan 1990).

Equipment

- Field guide (Murie 1954; Halfpenny 1987)
- Data forms
- Clipboard
- Pencils
- Maps
- Compass
- 0.75-m hoops
- 30-m measuring tape

Field Procedures

- Find the start of the transect, which probably will be along a road or trail.
- For each transect, establish 10 stations spaced 30 m (or the equivalent in paces) apart, with the first station 30 m from the start of the transect.
- At each station, establish two plots using a 0.75-m circular hoop; the centres of the plots should be 1.5 m from the transect.

- The plot on the right is referred to as Plot A, and the plot on the left side of the transect is referred to as Plot B (when facing forward on the transect).
- Walk along the transect and at each plot, search thoroughly for cottontail or hare pellets, counting any that are found.
- Record on data forms, all sign found in each plot.
- In addition, note the presence of any other sign of cottontails or hares. Field guides to identification of animal sign, such as Murie (1954) and Halfpenny (1987), may be useful.

Data Analysis

- Data analysis and interpretation are simply the compilation of the effort and results and an assessment of the evidence for the presence of a species in the study area.

3.3.2 Roadside Surveys (Eastern Cottontail)

Roadside counts of cottontails is a well-established technique for determining relative changes in abundance (Chapman and Willner 1986). Roadside counts involve driving roads at slow speed in early morning or late afternoon / early evening to observe cottontails. While this technique has been applied to Eastern Cottontails in Oregon, the published literature indicates that it has been critically examined only in the eastern and mid-western United States. No indication that roadside counts have been applied in B.C. was found.

Roadside survey is the standard way of assessing cottontail populations in many of the eastern and midwestern United States. In a 31-year data set from Missouri, Sadler (1981) found a close correspondence between roadside counts and the kill / gun hour. For the period 1947-1969 the correlation coefficient (r) was 0.815. The census route changed in 1970, and the value of r for 1970-1977 was 0.185. The change in r between the two census routes suggests that some areas may be more representative than others, but how to determine this is not clear.

Graf (1955) used this approach to study the distribution of cottontails derived from two introductions in western Oregon. He drove roads in the vicinity of the introductions during July 1953 from sunup until about 0800 "... and checked and rechecked until it was established with certainty that the maximum range extension had been determined."

Newman (1959) conducted counts of cottontails along two 20-mile (32 km) sections of road in Iowa in winter 1957 (1 January - 20 March). He began morning counts 1 h 20 min before sunrise and started evening counts 30 min before sunset. He alternated counts of the two areas between morning and evening. The automobile was driven at a speed of 15-20 mph (24-32 km/h), which means that each route could be surveyed in between 1 h and 1 h 20 min. Mean morning counts were about twice the mean evening counts (5.3 vs 2.7). For both times of day, cottontail activity decreased as light increased. Weather conditions, especially snow cover, affected counts; snow cover increased counts.

Lord (1959, 1961) studied the activity of cottontails year-round in central Illinois, as indicated by roadside counts. He found that peak activity was usually at night (Lord 1961). June was exceptional in that there was a peak of activity during early morning daylight hours. Cottontails seen per mile was usually highest during nighttime spotlight searches versus early morning visual searches (Lord 1959). However, during May, June, and July, morning visual counts were either higher than or similar to spotlight counts.

Kline (1965) confirmed Lord's (1959, 1961) findings during three years of survey along a 30-mile (48-km) stretch of gravel road in Iowa. He examined a number of weather factors and concluded that the maximum counts that resulted in early morning in July owed to the relative warmth and dryness of roads. Thus the peak counts occurred from 30 to 90 min. after sunrise. Of the weather factors examined in summer counts, he found a positive correlation with temperature and a negative correlation with wind velocity. In winter, snow depth positively influenced counts.

Fafarman and Whyte (1979) conducted nighttime surveys in south Texas and examined the factors that affected counts there. They found basically the same pattern that others had found, except that heavy rain decreased counts significantly. They also described a standard protocol that included a 3-min. wait after encountering another vehicle on the survey route, and an additional 3-min. wait before returning on the same route.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for project and study areas(s) (*e.g.*, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). At minimum, a 1:50 000 map of region is needed so that study area(s) can be delineated.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the project area from maps.
- Select study areas from maps that are likely to have suitable cottontail habitat. Do this by stratifying the project area by habitat or based on expected densities.

Sampling Design

- Counting the number of Eastern Cottontails seen along a standard stretch of road, at a standard time of day, during a standard season, is the most common means of measuring relative changes in density.
- A survey route should be between 30 and 50 km in length, along a lightly travelled road, where early morning traffic will not seriously interfere with the survey. It should be in an area where development is not likely to cause unacceptable increases in traffic levels. Reversing the route of travel on alternate survey days will help cancel biases that might occur if the same segments were always covered first and last.

Sampling Effort

- The road transect should be surveyed as many times as economically and logistically possible over the sampling season.

Sampling Standards

- Because there appear to have been no studies of Eastern Cottontails in B.C., or even Washington or Oregon, comparable to those conducted in the mid-western US, surveys should be designed to include the collection of data on certain weather conditions and time of day to determine what factors influence counts here.
- *Time of survey:* Based on survey results from the midwestern US, surveys should be conducted between 30 min before sunrise, and 60 min after, during the latter half of June and the first half of July. During June, activity extends into the morning daylight period and potentially interfering traffic should be minimal because of the early hour when the survey is conducted. Early morning surveys should avoid most traffic; however, if traffic is encountered, stop and wait for 3 min before resuming survey. Snow cover is highly variable during winter in the range of Eastern Cottontails in B.C., and this would argue against winter counts as the preferred time for surveys.
- *Weather:* Surveys should be conducted in all weather conditions, except high wind and heavy rain.

Personnel

- Only one person is required to conduct the roadside surveys, but it is useful to have a second person to record data.

Equipment

- Any safe automobile, pick-up truck, or similarly sized vehicle
- Tape recorder
- Data forms and pencils

Field Procedures

- Drive at 30-35 km/h along the survey route (transect of 30-50 km in length) so that the entire route can be driven within about 1 h 30 min.
- If traffic is encountered, wait 3 min before resuming survey.
- Record all cottontails encountered along the route.
- Reverse the route of travel on alternate travel days.

Data Analysis

- For each year, it will be possible to compute a mean and measures of dispersion (*e.g.*, standard deviation, standard error).

3.4 Relative Abundance

Recommended method(s): Pellet transects for Snowshoe Hare and Nuttall’s Cottontail; Roadside surveys for Eastern Cottontails.

For Snowshoe Hares, the fecal-pellet count procedure is straightforward and has a number of advantages with respect to accuracy, precision, and scheduling field work. The same approach will probably provide a good index of changes in population density of Nuttall's Cottontail; however, this approach has not been tested on that species.

For Eastern Cottontails, which occur on Vancouver Island and the Lower Mainland, late spring-early summer roadside counts are likely to provide a valid measure of changes in relative abundance.

3.4.1 Pellet Counts (Snowshoe Hare & Nuttall’s Cottontail)

Pellet-count surveys appear to have the potential of yielding accurate and precise abundance data, at least for Snowshoe Hares (Krebs *et al.* 1987) and possibly other leporids, while being simple to design and execute. Timing of the counts is not critical, as long as the ground is clear of snow, which permits considerable flexibility in scheduling fieldwork. Counts can be adjusted to an annual basis if the time between counts differs significantly from 12 months. The optimum shape of the plots should be determined for each species and habitat, since it will depend on the pattern of dispersion of fecal pellets. The resulting data also lend themselves to analysis according to habitat type. While this technique has been demonstrated for Snowshoe Hares in the southwestern Yukon Territory, it has not been applied to studies of other leporid species. Notwithstanding this, we believe that this approach is likely to yield valid information on relative changes in abundance.

Two approaches to assessing population size have used counts of fecal pellets. One involves determining how many pellets or pellet groups are deposited by an individual in a particular period of time. There is also a need to determine disappearance rates. The other involves clearing plots and recording the annual rate of deposition in those plots (Krebs *et al.* 1987), or clearing the plots in spring and fall to determine seasonal changes in habitat use (Litvaitis *et al.* 1985).

Krebs *et al.* (1987) showed a close relationship ($r = 0.94$) between number of Snowshoe Hares in their southwestern Yukon study area (as determined by mark-recapture) and the number of pellets deposited in study plots). They tested several quadrat shapes and concluded that a long, thin rectangle (5.08 cm x 305 cm; 2 in x 10 ft) produced results with the lowest variance. They set out the plots in a systematic 10 x 10 grid with 100 stations, which were also being used for live-trapping studies. Preliminary data suggested that 50 stations would estimate within ±20 percent of the mean; the 50 sampling plots were selected randomly from among the 100 stations.

At the start of the study, permanent markers were placed at each end and in the centre of each plot, and surveyors cleared the pellets from within these boundaries. Each June they returned to count and remove the pellets that had been deposited in each quadrat. Old pellets that had been kicked into the quadrats, possibly by hares, moose, or humans, were recognizable by their uniform dark grey colour and the lack of a light brown centre when they were broken open. While it is best to do the counts in the same summer month each year, the surveys could be done at any time when weather conditions permit. Counts could be adjusted to an annual rate to depict the average number of hares present over the course of a year.

Regression analyses were conducted with and without the constraint that the line had to pass through the origin and applying square root and logarithmic transformations. None of the manipulations improved the fit over the regression through the origin, which resulted in the predictive equation: mean hare numbers / ha = 0.2903 (mean number of pellets / plot / year). How much the coefficient might vary among widely separated areas is not known, and could be determined only by conducting a number of intensive studies. In the absence of additional data, we suggest that the pellet counts be used by themselves as an index of hare abundance without converting them to densities based on the Yukon data of Krebs *et al.* (1987).

Carter and Harestad (1991) and Carter *et al.* (1993) used pellet transects to determine presence of Nuttall's Cottontail and White-tailed Jackrabbit in the southern Okanagan and Similkameen valleys. They recorded the number of leporid pellets in two, 1-m^2 plots located at each of 10 stations along 300-m transects. The transects apparently were established at convenient locations, as opposed to randomly or systematically. They recognized the potential for confusing the pellets of young Snowshoe Hares and jackrabbits with those of the smaller cottontail, but while Carter (pers. comm.) saw both hares and cottontails during these surveys, there was no overlap in habitat. Cottontails were in lower elevation habitats, while hares were in treed habitats at higher elevations. They saw no jackrabbits.

Carter *et al.* (1993) state that the data of Sullivan *et al.* (1989) show a positive relationship between pellet density and population size between 1984 and 1985 on their intensive study area. While the relationship probably is positive, the data collected by Sullivan *et al.* (1989) cannot be used to determine that. The pellets counted on (and removed from) their Ponderosa Pine - sagebrush grid in 1984 had accumulated over an unknown number of years, while the number counted in 1985 was the accumulation from the previous year only.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual, *Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for project and study(s) (*e.g.*, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). At minimum 1:50 000 map of region is needed, so that study areas can be delineated.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the project area from maps.
- Delineate study areas which may reflect landscape-level differences in species abundance. Do this by stratifying the project area by habitat or based on expected densities.

Survey Design

- Systematic sampling along transects, stratified for habitat type. Within the areas of interest, select start points for 300-m transects, consisting of 10 stations at 30-m intervals.
- Replicate sampling should be used whenever possible.

Preliminary sampling

To determine the optimal size and shape of sample plots, conduct an analysis of turd counts on a minimum of 5 different plot sizes and shapes, each replicated 10 times. The following plot dimensions are suggested:

50 cm x 50 cm

25 cm x 100 cm

25 cm x 25 cm

10 cm x 150 cm

305 cm x 5 cm

Select an area in which to conduct the preliminary sampling. The area should be as uniform as possible and should be similar to the area in which the main program is to be conducted. The sampling points should be selected at random. It is critical that the plots be accurately defined.

Calculate the variance for each plot size and shape, and select the one that produces the lowest variance. If you are unable to do the preliminary sampling, use plots measuring 305 cm x 5 cm, the size and shape which Krebs *et al.* (1987) found to produce the lowest variance.

Sampling Effort

- There should be a minimum of 5 transects for each habitat type to be sampled.
- Annual fecal pellet counts should be made over a period of several years.

Time of Survey

- Pellet counts can be carried out at any time of year as long as the ground is free of snow.

Personnel

- Two persons are required to establish the plots in year 0, but afterwards, one person can revisit the plots to make annual fecal pellet counts.

Equipment

- Data forms
- Clipboard
- Pencils
- Maps
- Compass
- Handheld Global Positioning System (GPS)
- 30-m measuring tape
- Plot corner markers (1/4” rebar)
- Plastic flagging

- Roll of thin elastic string

Field Procedures

- Within the area of interest, randomly select the start points and orientations for the transects.
- The transects themselves will be straight lines, 300 m long with stations at 30-m intervals. Having regular intervals for stations will simplify relocating plots in future.
- Make detailed notes on the location and place a permanent marker at the start of each transect.
- Mark each sample site permanently, both on the ground and on a nearby tree (use stakes if sampling a treeless location). A small GPS (Global Positioning System) will enable you to relocate sites to within 15 m.
- Each sample plot must have permanent markers placed at each corner (and in the middle if it is a long, thin plot). A thin elastic string that can be stretched between plot corner posts will make it easier to define the plot; suitable material can be obtained at a sewing supply store. Suitable corner markers can be made from $^{1}/_{4}$-inch reinforcing steel ("rebar"). Consider fabricating a template to ensure that plots are laid out accurately and consistently.
- When establishing each sample plot (year 0), count all leporid pellets within the plot boundaries. It is important that only those pellets lying within or on the plot boundaries be tallied. All turds from within or near the plots must be removed well away so that they will not be kicked back into the plot. While pellet counts from year 0, which will have accumulated over more than one year, cannot be compared directly with counts in future years, they may provide useful information on relative habitat use.
- In year 1 and subsequent years, count and record the number of pellets that have accumulated in each plot, again being scrupulous about counting only those pellets that are within the plot or touching the plot boundaries. This latter point is especially important when the plot shape is long and narrow, so that the perimeter : area ratio is large.

Data Analysis

- Conduct analyses of variance to compare areas, habitats, and years.

3.4.2 Roadside Surveys (Eastern Cottontail)

This technique is also used for presence/not detected surveys. Only differences from the presence/not detected survey are listed here. For details on how to conduct this type of survey see section 3.3.2.

Sampling Effort

- The road transect should be surveyed as many times as economically and logistically possible over the sampling season.
- It is recommended the survey be repeated over several years to reveal trends over time.

Data Analysis

- For each year, it will be possible to compute a mean and measures of dispersion (*e.g.*, standard deviation, standard error).
- After several years, it will be possible to look at differences among years and examine trends.

3.5 Absolute Abundance

Recommended method(s): Mark-recapture for Snowshoe Hares, Nuttall's Cottontail and Eastern Cottontail.

3.5.1 Mark-recapture

Estimating absolute abundance of hares and cottontails is best accomplished by a mark-recapture approach, which involves a rather intensive level of effort.

Mark-recapture methodologies for the measure of absolute abundance of cottontails and hares have been extensively field tested. The mark recapture approach to studying cottontail and hare populations has been used with considerable success (Chapman and Willner 1986).

Anyone involved in trapping, handling, and/or marking of hares or cottontails should be familiar with provincial standards outlined in the manual, *Live animal capture and handling guidelines for mammals, birds, amphibians, and reptiles* (No. 3).

Assumptions

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

- **Population closure**: It is assumed that the population is closed (*i.e*., no immigration, emigration, births, or deaths occur), so that the population size does not change over the period of the experiment. For rabbits and hares, both seasonal and annual changes in population size are possible. From a practical estimation viewpoint, the closed population assumption can be completely relaxed if more than 40 percent of the population is marked (each individual must be given a unique mark) for at least 4 consecutive sampling intervals and a Jolly-Seber analysis procedure is used (Seber 1992). A partial relaxation of the assumption is possible if the following conditions are met: (1) movement of itinerants (recruitment) into the study area is negligible in comparison to the overall precision of the study; (2) marked and unmarked animals are equally likely to die or leave the study area; and, (3) all marks are applied over a short period of time prior to any recapture effort.
- **Recapture probabilities**: It is assumed that the probability of capturing a marked individual at any given time is equal to the proportion of marked members in the population at that time. It is important to note that the assumption relates to the recapture of marked animals in comparison to unmarked animals and not to the application of marks. The problems with respect to possible sex bias and responses to traps discussed above furnish mechanisms for violation of this assumption. The impact of these problems on the population estimate can be reduced by marking and sampling intensively. Seber (1992) recommends that the total number of animals marked and examined during the entire experiment should exceed the population size if problems are suspected. Alternatively, the heterogeneous analysis model (Otis *et al.* 1978) can be used to obtain nearly unbiased population estimates if the marked animals exhibit heterogeneous capture probabilities as would be found in the entire population (*i.e*., the

marked animals represent a random sample of the population even though subsequent recapture probabilities are heterogeneous). Since this model requires as input the number of animals captured at least once, twice, thrice and so on, we must have the ability to identify individuals when captured (*e.g.*, a unique code for each marked animal). The heterogeneous model is not available for the fully open population regime (*i.e.*, Jolly-Seber type).

- **Lost marks**: It is assumed that animals do not lose their marks over the period of the study. The type of mark used and the length of the study are the obvious factors. If marks are lost then the experiment results in over-estimates of population size (termed negative bias). Why this is true can be seen from the basic Petersen formula:

  $$N = CM / R, \text{ where}$$

  N = estimated size of population

  M = number of individuals marked in the first sample

  C = total number of individuals captured in the second sample

  R = number of marked individuals in the second sample

  If R is believed to be smaller than it really is, N will be calculated to be larger than it should be, thus over-estimating the population size. N is very sensitive to changes in R.

- **Missed marks**: It is assumed that all marks are reported (detected) on recovery. Recapture techniques in which the animals are not handled (*e.g.*, observed for a mark from a distance) are the most prone to this problem. As with lost marks, missed marks result in an over-estimate of population size and for the same reason.

Models for determining population size

The mark-recapture analytical model selected to obtain population estimates will help specify design criteria and the sensitivity of estimates to assumption violations. For rabbits and hares, the following three models are possible candidates: (1) the Schnabel closed population model, (2) the Jolly-Seber open population model and (3) the heterogeneous model for time invariant closed populations (there is not an open population counterpart).

If each animal receives a unique mark, then the protocol for the Schnabel and Jolly-Seber models are similar (*i.e.*, both use multiple mark-recapture sampling sequences) and, if necessary, the analytical approach can be decided after the program has been conducted. However, if heterogeneous capture probabilities are suspected (*e.g.*, trap happy or trap shy individuals), then all marks should be applied before recapture efforts are launched. While estimation techniques have been developed to deal with time variant heterogeneous capture probabilities (*i.e.*, marking and recapture effort conducted sequentially over time), they have not performed very well in practice for most species (Seber 1992) nor specifically for snowshoe hare (Boulanger 1993).

A simple yet powerful statistical test for heterogeneity of capture probabilities is a goodness-of-fit test under the null hypothesis that the recapture frequencies (*i.e.*, number of times individuals are recaptured) are binomial in distribution. Therefore, in situations where there is little prior knowledge of the population of interest, we recommend that the test be conducted while the study is in progress. Conversely, tests for closure are more complex and can be found in the major mark-recapture software packages CAPTURE (Otis *et al.* 1978), JOLLY (Pollock *et al.* 1990), and POPAN-2 (Arnason and Baniuk 1978). Since these tests are not very powerful, we recommend that the closure decision be based primarily on biological arguments. For example, if a study was conducted over a sufficient time period to expect recruitment (or mortality, etc.), the Jolly-Seber procedure should be applied.

Grid size and trap spacing

Many workers have set out traps in some sort of grid pattern. In their study of Snowshoe Hares near Prince George, B.C., Sullivan and Sullivan (1983) established 10 x 10 grids, with 33.3 m between points. However, they placed traps at every other station, effectively yielding a 5 x 10 grid with 33.3 m spacing in one direction and 66.7 m spacing in the other. Krebs *et al.* (1986), working in the southwestern Yukon, established a 10 x 10 grid, with 30.5 m between stations. During periods of low density, they set traps at alternate positions in the grid, but as density increased, they increased the number of traps up to 100. Working near Prince George, B.C., Sullivan and Sullivan (1983) used the approach as did Krebs *et al.*

In their study of an Eastern Cottontail population on an island in Maryland, Bittner and Chapman (1981) distributed traps where they thought the chances were best for making captures. They made no attempt to obtain even trap coverage.

In their study of Nuttall's Cottontail in southern B.C., Sullivan *et al.* (1989) established a 25.6 ha grid of 232 stations 30 m apart. They placed live traps at every other station. McKay and Verts (1978a,b) used a much wider spacing. They established a 9 x 13-trap grid, with 90 m between traps.

Trapping schedule

Most investigators place traps in their study areas for extended periods. The traps are left in the 'locked open" condition, except when actually trapping. Sullivan and Sullivan (1983) trapped Snowshoe Hares for two nights every four weeks. The traps were set on day 1, checked on day 2, and checked and locked open on day 3. Krebs *et al.* (1986) followed essentially the same schedule.

Bittner and Chapman (1981) live-trapped an Eastern Cottontail population in Maryland during July and August and again in December, apparently once per month. They did not leave the live-traps in the field, but deployed them at each sample period. They trapped for three nights, checking the traps on days 2, 3, and 4.

Sullivan *et al.* (1989) trapped for 2 or 3 nights every 3 weeks from spring through early fall of their study of Nuttall's Cottontail. In the one winter when they trapped, the intervals were 4 to 12 weeks. McKay and Verts (1978a,b) trapped for 30 consecutive days in August 1972 and 1973, for 3 days on alternate weekends in April and May, and for 3 days each week during June and July 1973. (It is not clear from McKay and Verts description whether they trapped for 2 or 3 nights.)

Trap response

Chapman and Willner (1986), without citing supporting evidence, state that there is a tendency for some individual leporids to become "trap-happy" and others "trap-shy".

Cottontails: Cottontails readily enter wooden box traps, with dimensions of 20 x 20 x 61 cm (8 x 8 x 24 inches) (Chapman and Edwards, pers. comm.). While some investigators use bait, such as apple or oats, Chapman and Edwards (pers. comm.) believe that bait is unnecessary, and Edwards (1975) cautions that baits will attract rodents which may occupy and/or damage the trap. Chapman also believes that it is important, however, to "season" the trap with cottontail urine. This can be done by collecting cottontail urine, diluting it with water, and spraying it into a box trap, or by keeping a cottontail in the trap overnight before deploying it. Chapman (pers. comm.) believes that it is not necessary for the trap to be "weathered", while Edwards (pers. comm.) thinks that weathering is helpful.

Eastern Cottontails: Chapman and Trethewey (1965) reported factors that affected trappability of Eastern Cottontails in western Oregon. Using wood box traps as described above, they found that age, sex, and weather affected susceptibility to capture. Although cottontails were captured initially in a 1:1 sex ratio, they found that males subsequently became significantly more difficult to recapture; hunting returns from the same area also showed a 1:1 sex ratio. Juveniles were also more easily recaptured than were adults. There was a positive relationship between barometric pressure and captures per trap-night, and an inverse relationship with temperature. Precipitation had no effect.

Nuttall’s Cottontail: In their study of Nuttall's Cottontail in southern B.C., Sullivan *et al.* (1989) used wire live traps (23 x 23 x 80 cm) baited with apples and alfalfa cubes. They found this species difficult to trap, but it is possible that this species might be more trappable using wooden box traps of the sort described above, as did McKay and Verts (1978a,b).

Snowshoe Hare: Wire live traps, such as the Tomahawk No. 205 (23 x 23 x 66 cm), are effective for trapping Snowshoe Hares. Krebs *et al.* (1986) baited the traps with apples in summer and alfalfa (lucerne) cubes in winter. Sullivan and Sullivan (1983) and Sullivan (1990) used both apples and alfalfa cubes. Litvaitis *et al.* (1985) working in Maine, found that capture rates were higher when traps were baited with alfalfa hay than when they were baited with apples, vanilla extract (as an attractant), or not baited; they trapped in April-May and October-November.

Keith and Meslow (1968) studied the response of Snowshoe Hares on a study area near Edmonton, Alberta. They set wire traps on runways where natural vegetation tended to restrict lateral movements. Where vegetation was sparse, they added sticks and brush to direct animals into the traps. They baited traps with alfalfa hay, but abandoned the practice in summer after they found higher success with unbaited traps. They believed that the hay partially blocked visibility through the traps, and thereby discouraged entry. On the other hand, Snowshoe Hares appear to be strongly attracted to green vegetation in winter, and baiting with green alfalfa hay was effective then. The hay also provided food and probably some insulation from the trap's metal floor.

Keith and Meslow (1968) compared their live-trapping results at various seasons and with results of other methods of sampling the population (*e.g.*, drive-netting, live-snaring, visual observation of colour-marked and unmarked animals). Their analysis indicated that hares were captured randomly by the live traps, and that an individual's probability of capture in one trapping period was independent of whether it had been captured in a previous period. They concluded that the use of captures by live traps in mark-recapture studies of Snowshoe Hares was valid.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual*, Species Inventory Fundamentals* (*No.1).*
- Obtain relevant maps for project and study area(s) (*e.g.,* 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps). At minimum 1:50 000 map of region is needed, so that study area(s) can be delineated.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for the project area from maps.
- Delineate study areas which may reflect landscape-level differences in species abundance. Do this by stratifying the project area by habitat or based on expected densities.

Sampling Design

- Systematic sampling using a grid system.
- Set out a systematic grid system on a map of the study area using spacing of 30-60 m. If there are fewer than 5 rows or columns or the sum of the rows and columns is less than 20, then consider abandoning the study because it is likely that small sample size will result in unacceptably poor precision and accuracy. On the ground, locate the live-trap in the most favourable habitat (near objects such as rocks or trees, partially under bushes, or in runways) within a radius of 25 percent of the spacing distance about the theoretical grid intersection. If a suitable habitat for the trap cannot be found within the designated area, then the trap should not be deployed.
- Typically, the trap spacing for a 10 station by 10 station grid would be 33.3m (about 300 m square). When population densities are low, place traps at alternative stations (grid intersections) along each row and column transect. Because cottontails and hares that are present within the grid will range outside by some considerable distance, a minimum buffer of 200 m of habitat similar to that within the grid should be included within the scheme.
- The objective is to obtain a sample of the population that is as representative as possible, or alternatively, mark a very large part of the population. Stations should be close enough to maximize the probability of trapping an animal within a reasonable time. The longer that stations operate and the higher the density of stations, the greater the probability that an animal will visit a trap.
- Ripley (1981) showed that the most efficient sampling design for a spatially contagious distribution (*i.e.,* heterogeneous capture probabilities in our case) is a grid which is either systematic or nonaligned systematic (a sampling event is chosen at random within a prescribed distance of a fixed grid intersection). For rabbits and hares, a nonaligned systematic grid could be achieved simply by placing the live-trap in the most favourable habitat within a specified distance (*e.g.*, 25 percent of spacing distance) of a grid intersection.
- The spacing of stations reflects the desired sampling intensity. Most authors recommend four stations per home range (e.g., Otis *et al.* 1978) to combat the lack of equal access if traps were far apart relative to home range size, although no mathematically rigorous criteria is given for this level of sampling. Work done by Ripley (1981) based on spatial sampling of theoretical contagious distributions (a mathematical statistics exercise) supports the notion that multiple stations within a home range are necessary. Assuming,

for design purposes, a square home range (the most efficient shape to pack home ranges within a given area) and 4 traps per home range, then the spacing *(s)* should be:

$$s \leq \frac{\sqrt{A}}{2}$$

where *A* is the area of the home range. However, in nearly all of the studies that we reviewed, the spacing schemes were much denser than 4 traps / home range.

Choosing a model

For rabbits and hares, the duration (length) of the study and the season in which it is conducted will to a large extent, determine the validity of the closure assumption. If the study can be conducted over a short period (*e.g.,* a few weeks) during which movement and dispersal are minimal (*i.e*., late winter - early spring), then the Schnabel or heterogeneity model can be applied. The Jolly-Seber model will have to be used for longer studies where it is clear that the closure assumptions are significantly violated. See **Data analysis** for a detailed discussion of the use of specific models.

Sampling Effort

- To obtain reliable estimates of population size, a sufficiently large sample size must be taken. For sample size determination, a conservative approach is to assume that cottontails and hares are not at all territorial, but mix much like a population of fish. Complicated mathematical sample requirements are given by Burnham *et al.* (1987) for a specified population size, precision, and power. Seber (1982,1992) points out that considerable mark-recapture experience has shown that complex algorithms are not really required. If less than 20 percent of the population has been marked, then the estimates are likely not reliable. It is not until 40 percent of the population has been marked that the estimates become highly plausible. Thus, at least 20 percent and preferably 40 percent or more of the population should be marked. Seber further states that the recovery effort should be approximately equal to the marking effort. For sequential sampling, approximate equivalency between the marking and recovery efforts is inherent in the design.
- Marking and recapture efforts can be extended up to two months; however, the Jolly-Seber open population estimation model must be used, with a minimum of three (preferably four or more) sampling periods.

Sampling Standards

- Of the factors that affect capture probabilities, time is the one most easily controlled by the biologist. The biologist can select the season of the year that the studies are to be conducted and the length of the sampling period. In both of these decisions, the objective is to maximize capture-recapture efficiency and to reduce variation in capture probabilities over time.
- Time of year: The mark-recapture experiment should be conducted in the late winter - early spring period. If the closed population models seem acceptable (see Data analysis, below) the duration should be 2-3 weeks.

Personnel

- Two personnel are recommended to carry out mark-recapture studies.

Equipment

- Data forms
- Field notebook and pencil
- Flagging
- Traps (see **Field Procedures**)
- Bait or seasoning (alfalfa cubes, apple, fresh cottontail urine)
- Marking equipment (tags, hair dye, coloured plastic discs, alcohol-picric acid solution, *etc.)*
- See Capturing and Handling Protocol manual for additional equipment.

Field Procedures

- While capturing and marking animals proper protocol must be used (See Capture and Handling Protocol Manual).
- Lay out traps in a grid system as described in the section on Sampling design.
- Choose the appropriate trap(s) for the focal species.
- Trapping should take place for 3 nights every two weeks.
- On day 1, the traps should be set.
- On days 2, 3, and 4, the traps should be checked.
- Between trapping sessions, the traps should be left on the grid in the locked-open position.
- Record the number of marked and unmarked animals on each trapping day.
- All unmarked animals in the traps should be be marked on days 2 and 3 (see ***Marking*** below).
- After marking is complete and all data recorded, release the animals.

Traps

- For Snowshoe Hares, use wire Tomahawk live traps (No. 205, 23 x 23 x 66 cm; Tomahawk Live Trap Co., Tomahawk, WI, USA), or similar models, baited with alfalfa cubes in winter or apple in summer.
- For Eastern Cottontails, use wooden traps, such as that shown in Figure 1. Cottontail traps should not be baited, but should be seasoned with fresh cottontail urine just before use. This can be accomplished by keeping a cottontail overnight in a trap or by spraying traps with cottontail urine diluted 1:1 with water. Allow the trap to weather in sun and rain, if possible.
- The optimum trap for Nuttall's Cottontails has not been determined, and a test should be run to find out which of the traps described above is most effective.

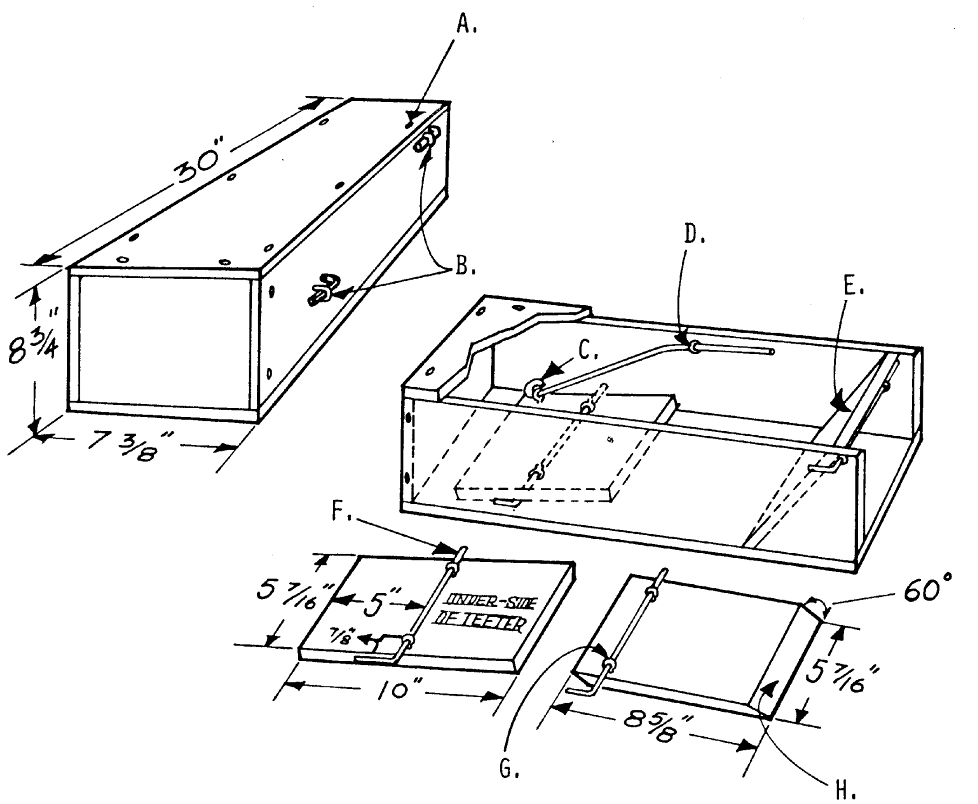

Figure 2. Design of a wooden trap for Eastern Cottontail. (Source: Illinois Natural History Survey.)

Table 3. Design of a wooden trap for Eastern Cottontail: Parts List

Item	Quantity	Description
Board	12 feet long	1” x 8”
Nails	20	No. 8 or 10 Common
Wire	40”	Galvanized, Number 9
Screw Eyes	6	To fit Number 9 Galvanized Wire

General Instructions

A. Nails used in the trap are common Number 8 or 10. Eight nails are used to attach the top and eight are also used in the bottom. Two nails are used in each side at the enclosed end of the trap.

B. Hinge wires when inserted in the trap are held in place with staples.

C. The trip wire is 17” long and is bent approximately in a 13^0 arc. The bend begins approximately 4 1/2” from the hooked end. After the trap is assembled, the trip wire may be readjusted for proper tripping. To make the hook on the trip wire, start the bend approximately 1 1/2” from the end of the wire. Be sure to insert the eye screw before completing the bend in the wire.

D. The screw eye which is the guide for the trip wire is located 13” from the front of the trap and 1 1/2” down from the top.

E. The inside of the trap door may be lined with galvanized metal in order to inhibit gnawing.

F. One end of the hinge wire is not bent, and when it is inserted into the trap, it is to be flush with the outside wall of the trap. The hole for this teeter hinge is to be drilled 3/4” up from the edge of the board and 9” from the closed end of the trap. The opposite end of the hinge wire is bent at a right angle and fastened to the side of the trap with a staple.

G. Screw eyes for the trap door are situated 1” from the end and 1” from the side. The hole for this hinge wire is situated 1 1/4” from the open end of the trap and 1 1/4” down from the top edge of the board.

H. Both ends of the trap door are beveled at a 60^0 angle. When cutting these angled ends, be sure to keep the cut side facing up in order to have both ends beveled in the same direction of the trap door will not rest snugly on the trap floor when the trap is sprung. In other words, if you’re using a table saw, make one cut on the right side of the blade for the right end of the board and one cut on the left side of the blade for the left side of the board. Do not turn your board over in the process of cutting either of these angles.

General Information

1. Do not bait the trap for rabbits. Baiting will attract gnawing rodents.

2. Set the trap in an “open” area near cover, along trails or mowed paths.

3. Check your trap daily and as soon after sunrise as possible.

4. Paint the outside face of the trap door any bright colour, white, re, etc. This will act as a visual aid in determining whether the trap has been sprung.

5. Check your local laws regarding the trapping of wildlife.

Marking

It is recommended that leporids be marked with a method that is permanent for the duration of the sampling period, will not affect the behaviour of the animal, and is humane. Suitable methods include No. 3 monel ear tags, hair dye, coloured plastic discs, alcohol-picric acid solution (for marking pelage), and notching or punching holes in ears. Marking pelage, of course, lasts only until the next moult (Wolff 1982; Chapman and Willner 1986).

Keith *et al.* (1968) reported several means for marking Snowshoe Hares. Picric acid-alcohol solution produced a bright yellow colour; rhodamine B (pink) also produced satisfactory results. They looked for differences in mortality between yellow-rumped and unmarked hares and found none. They tattooed ears using a Franklin Rotary Tattoo, which they found produced good results. No. 1 self-piercing fingerling fish tags, placed on the interdigital webs of the hind feet also worked well. The fingerling tags were crimped behind the intercapitular ligament, one on each hind foot. Of 98 tagged hares that were recaptured 1-13 months after tagging, only 9 had lost one tag and none had lost both.

Krebs *et al.* (1986) marked Snowshoe Hares with No.3-size monel ear tags. They also used ear tattoos and plastic ear tags in the early years of their study, but found so little tag loss that they ultimately have used ear tags only. Sullivan *et al.* (1989) and Sullivan (1990) also found insignificant loss with No. 3 monel ear tags. Bittner and Chapman (1981) marked Eastern Cottontails with metal ear tags during a mark-recapture population study, as did Sullivan *et al.* (1989) in their study of Nuttall's Cottontail.

Data Analysis

Boulanger and Krebs (1994) evaluated capture-recapture estimates applied to a cyclic Snowshoe Hare population in southern Yukon and found the heterogeneity model with a jackknife estimator (Otis *et al.* 1978) to be the superior procedure compared to several other models. This technique is described in more detail below.

Computer software (POPAN-2) for all the suggested procedures discussed below can be obtained from Carl J. Schwarz, Department of Statistics, University of Manitoba, Winnipeg, MB R3T 2N2.

Population closure and capture probabilities (homogeneous or heterogeneous) are the two selection criteria that define the analytical mark-recapture model required for population estimation. In situations where there is little prior knowledge of the population of interest, first conduct a goodness of fit test under the null hypothesis that the recapture frequencies (*i.e.*, number of times individuals are recaptured) are binomial in distribution. As discussed above, the closure decision will likely be based on the duration of the experiment. Choose one of the following analytical approaches based on these criteria:

1. **Heterogeneous model:** The heterogeneous model should be applied if the population is closed and the recaptures are heterogeneous. Group the sampling sequences (the entire experiment) into a release and a recapture period with approximately equal sampling efforts. Ignore recaptures made in the release period and ignore releases made in the recapture period. Use the jackknife estimator described by Otis *et al.* (1978: p109) on the remaining data. They list the first 5 jackknife expansions about the total number of animals trapped (M_{t+1}). For our mark-recapture scheme, the largest order that can be used equates to the maximum number of times any individual was captured. If an individual is recaptured more than 5 times, the presumption that f_5 represents 5 or more recaptures will yield a good approximation. Therefore, select an estimation equation listed below based on the order (up to 5):

$$\hat{N}_{h1} = M_{t+1} + \left(\frac{t-1}{t}\right) f_1$$

$$\hat{N}_{h2} = M_{t+1} - \left(\frac{2t-3}{t}\right) f_1 - \frac{(t-2)^2}{t(t-1))} f_2$$

$$\hat{N}_{h3} = M_{t+1} + \left(\frac{3t-6}{t}\right) f_1 - \left(\frac{3t^2-15t+19}{t(t-1)}\right) f_2 + \frac{(t-3)^2}{t(t-1)(t-2)} f_3$$

$$\hat{N}_{h4} = M_{t+1} + \left(\frac{4t-10}{t}\right) f_1 - \left(\frac{6t^2-36t+55)}{t(t-1)}\right) f_2 + \left(\frac{4t^3-42t^2+148t-175}{t(t-1)(t-2)}\right) f_3 - \frac{(t-4)^4}{t(t-1)(t-2)(t-3)} f_4$$

$$\hat{N}_{h5} = M_{t+1} + \left(\frac{5t-15}{t}\right) f_1 - \left(\frac{10t^2-70t+125}{t(t+1)}\right) f_2 + \left(\frac{10t^3-120t^2+485t-660}{t(t-1)(t-2)}\right) f_3 - \left(\frac{(t-4)^5-(t-5)^5}{t(t-1)(t-2)(t-3)}\right) f_4 + \frac{(t-5)^5}{t(t-1)(t-2)(t-3)(t-4)} f_5$$

where t is the number of sequences (sampling days), Nhk is the jackknife estimator of the k'th order, Mt+1 is the number of distinct animals caught during the study and fj is the number of animals captured exactly j times in t nights (capture frequencies).

$$M_{t+1} = \sum_{j=1}^{t} f_j$$

Because any Nhk is expressible as a linear function of the capture frequencies:

$$\hat{N}_{hk} = \sum_{j=1}^{t} a_{jk} f_j$$

Using the fact that f_j are multinomial random variables an approximate variance estimator is as follows:

$$\hat{Var}\left(\hat{N}_{hk}\right) = \sum_{j=1}^{t} \left(a_{jk}\right)^2 f_j - \hat{N}_{hk}$$

and confidence intervals can be constructed on the basis of asymptotic normality.

2. **Schnabel model**. If the population is closed and the recaptures are homogeneous, the Schnabel model can be applied. The information with regard to recapture of individuals is not required. Thus, the data should be organized into the following three vectors:

Mt = total marked animals at large at the start of the t'th sampling interval;

Ct = total number on individuals sampled during interval t; and

Rt = number of recaptures in the sample Ct.

An approximation of the maximum likelihood estimate of population size (N) is:

$$\hat{N} = \frac{\sum_t \left(C_t M_t\right)}{\sum_t R_t}$$

Confidence limits can be computed by treating the sum of recoveries as a binomial variable and entering the associated limits into the maximum likelihood estimate equation. Exact iterative solutions are available in Darroch (1958). If Bayesian posterior probability estimates are desired (*e.g.*, produce a cumulative or risk probability plot for minimal population estimates) then consult Gazey and Staley (1986).

3. **Jolly-Seber model**. Where the population is open and recaptures are homogeneous, apply the Jolly-Seber model. For most sampling sequences the model estimates the population size at time *t*, the survival rate of animals from time *t* to *t+1* and the number of animals that join the population (recruitment) between time *t* and *t+1* and survive to time *t+1*. When the model allows for removals its formulation becomes complex. Interested readers should consult Pollock *et al.* (1990). We recommend the use of the computer software package POPAN-2 (Arnason and Baniuk 1978), if this model is selected.

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.

ANALYSIS OF VARIANCE: A statistical method designed for multisample (three or more) analyses.

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

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

CORRELATION COEFFICIENT (r): The statistical measure of the linear reltaionship between two variables, where neither is assumed to be functionally dependent on the other.

ECOPROVINCE: Geographic region with broad similarities in climate and topography. Are futher divided into ECOREGIONS and ECOSECTIONS.

EXTIRPATED: An extirpated species no longer exists in the wild in British Columbia, but occur elsewhere.

GLOBAL POSITIONING SYSTEM (GPS): System using signals from two or more satellites to determine the location (latitude and longitude) of the person, vessel or aircraft.

GOODNESS OF FIT TEST: A statistical measure of how well a sample distribution deviates from a theoretical distribution.

HETEROGENOUS MODEL: A mark-recapture model applied to closed populations where recaptures are heterogenous.

HOME RANGE: The area in which an animal normally lives.

JOLLY SEBER OPEN POPULATION MODEL: A mark-recapture model applied to open populations where recaptures are homogenous.

LEPORID: A species belonging to the taxonomic family Leporidae.

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

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

NULL HYPOTHESIS: Statistically, a statement of no difference, the truth of which is then tested . In contrast to the ALTERNATE HYPOTHESIS. A null and alternate hypothesis are stated for each stastical test performed.

PELLETS: A term used to describe the fecal droppings if hares and cottontails.

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 generally takes place within smaller study areas within this project area.

QUADRAT: A sampling unit used to assess the density of organisms. Etymologically, it means a four-sided figure, but in practice refers to any sampling unit, whether circular, regular or irregular polygon, or any other shape.

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

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

REGRESSION ANALYSIS: A statistical method designed to test the dependence of one variable on another.

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.

SCHNABEL CLOSED POPULATION MODEL: A mark-recapture model applied to closed populations where recaptures are homogenous.

STANDARD DEVIATION: A statistical measure of dipersion of data; the positive square root of the VARIANCE.

STANDARD ERROR: A statistical measure of dispersion of a statistic; The standard deviation of the mean.

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

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

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

SYCHRONOUS POPULATION CYCLES: When population cycles occur within the same period of time.

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

TRANSECT: A survey technique where observers count all specimens of interest (i.e., pellets, hares, etc.) within a predetermined radius of a “line” travelled by the observer.

VARIANCE: A statistical measure of dispersion of data; the mean sum of squares of the deviations from the mean.

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

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