*Ground-based Inventory Methods for Ungulate Snow-track Surveys

Standards for Components of British Columbia's Biodiversity No. 33a

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For:
Ministry of Environment
Ecosystems Branch
for the
Resources Inventory Committee

July, 2006

Version 1.0

* **Addendum to Ground-based Inventory Methods for Selected Ungulates: Moose, Elk and Deer. Standards for Components of British Columbia's Biodiversity No. 33.**

Published by the Resources Information Standards Committee

Library and Archives of Canada Cataloguing in Publication Data

D'Eon, Robert G. (Robert George), 1964-

Ground-based inventory methods for selected ungulates: Moose, Elk, Deer [electronic resource].

[Standards for components of British Columbia's biodiversity ; no. 33a]

Title from cover of PDF file.

Available on the Internet.

"Addendum to Ground-based inventory methods for selected ungulates: Moose, Elk, Deer. Standards for components of British Columbia's biodiversity, No. 33"

Previously issued by Resources Inventory Committee, 1998.

ISBN 0-7726-5543-X

1. Ungulates – British Columbia – Handbooks, manuals, etc. 2. Mammal surveys - British Columbia – Handbooks, manuals, etc. 3. Ecological surveys - British Columbia – Handbooks, manuals, etc. I. Wilson, Steven F. II. Hamilton, D. (Dennis). III. British Columbia. Ecosystems Branch. IV. British Columbia. Resources Information Standards Committee. V. Title.

QL737.U4 G76 2006   333.95'961109711   C2006-960074-0

Digital Copies are available on the Internet at:
http://ilmbwww.gov.bc.ca/risc/index.htm

Preface

This report represents standardized methodology for conducting winter snow-track surveys of selected ungulates in British Columbia. The standards were compiled for the Ecosystems Information Section, Ecosystem Branch of the Ministry of Environment by a team of consulting biologists with experience in conducting ungulate snow-track surveys in British Columbia.

The decision to use snow-track surveys for ungulates must be based on consideration of the limitations of other methods and options (RIC 1998). Snow-track surveys evolved from a need to survey ungulates during winter seasons within heavily forested and often mountainous terrain where other methods such as aerial surveys are impractical and snow-track surveys are the appropriate option.

The number of transects conducted is usually constrained by available resources; however, it is important to conduct sufficient sampling to achieve the objectives of the study. The following considerations govern the number of required samples:

1. The expected variability among samples (anticipated distribution of individuals–a clustered distribution requires more samples);

2. Whether the intended measure is presence/not detected or relative abundance;

3. Sampling “efficiency” (likelihood that animal use is detected); and

4. The number of contrasts to be examined with the data (e.g., relative use between early and late winter, between drainages, or between species).

It is important to ensure compatibility with provincial data systems, so project information and data that must be reported in the Wildlife Species Inventory data capture tool is outlined in the report. For more information about the WSI system or to provide comments or feedback, visit http://srmwww.gov.bc.ca/wildlife/wsi/index.htm.

Acknowledgments

The Government of British Columbia provides funding for the Resources Information Standards Committee (RISC) work, including the preparation of this document. The RISC supports the effective, timely and integrated use of land and resource information for planning and decision making by developing and delivering focused, cost-effective, common provincial standards and procedures for information collection, management and analysis. Representatives to the Committee and its Task Forces are drawn from the ministries and agencies of the Canadian and the British Columbia governments, and include academic, industry and First Nations involvement.

The RISC evolved from the Resources Inventory Committee, which received funding from the Canada-British Columbia Partnership Agreement of Forest Resource Development (FRDA II), the Corporate Resource Inventory Initiative (CRII) and by Forest Renewal BC (FRBC), and addressed concerns of the 1991 Forest Resources Commission.

For further information about the RISC, please access its website at: http://ilmbwww.gov.bc.ca/risc/index.htm.

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Introduction

Observing and counting wildlife tracks in snow is a common practice with a long history. Snow-track count surveys have been used extensively in studies of forest-dwelling mammals such as Marten (*Martes americana*), Lynx (*Lynx canadensis*), and Snowshoe Hare (*Lepus americana*; Livaitis et al. 1985; Thompson et al. 1989; Stanley and Bart 1991; Norrdahl and Korpimaki 1995; Zielinski and Kucera 1995; Kurki et al. 1998; Zalewski 1999; Kauhala and Helle 2000; Robitaille and Aubry 2000; Hoving et al. 2004). Researchers have refined techniques to enable trail detectability, taking into account variation in track size, exposure to weather, and time since last snowfall (Beauvais and Buskirk 1999). Snow-track surveys have been used in Alberta as a generic method for gathering species and habitat information for a number of species (Bayne et al. 2005).

Surveys of ungulate tracks have generally focussed on obtaining population indices (e.g., Kie 1988; Single et al. 1989; Fritzen et al. 1995). D'Eon (2001) used snow-track counts to study mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) habitat use, distribution, and relative abundance in a broad-scale, multi-year survey using a stratified random sampling in southeastern BC. Elsewhere, Proulx and Kariz (in press) used snow-track count surveys to determine moose winter habitat use in the BC central interior.

Nyberg et al. (1985) and Waterhouse et al. (1988, 1990) were among the first in BC to use systematic transect surveys to determine ungulate distribution and habitat relationships. In southeastern BC where mountainous terrain coupled with tall, dense coniferous forests often precludes aerial census techniques, snow-track count surveys for ungulates were used widely by D'Eon and Bialkowski (2000), Poole et al. (2001), Poole and Mowat (2002a,b), Poole et al. (2003), and Serrouya and D'Eon (2002, 2003). These surveys used straight-line transects oriented uphill, since elevation was the largest ecological gradient. Target species were limited to deer, elk, and moose. Transects were located using random or systematic sampling design to capture the ecological variability in a particular study area. The location of each track or trail that crossed a transect was recorded. Spatial distribution and habitat use of ungulates was determined over broad areas by determining the correlation between track locations and several pertinent habitat parameters.

When to Use Snow-track Count Surveys

Snow-track count surveys were developed to survey ungulates during winter seasons within heavily forested and often mountainous terrain where other methods such as aerial surveys were impractical. Often snow-track count surveys are the only option for obtaining ungulate winter range data.

Use snow-track count surveys to determine the spatial distribution of local ungulate populations during the winter in areas where aerial census methods are not feasible.

Office Procedures

- Review "Conducting a Wildlife Inventory" in the introductory manual, *Species Inventory Fundamentals No. 1* (http://srmwww.gov.bc.ca/wildlife/wsi/manuals.htm).

- Assess the applicability of snow-track count methods for the species of interest in relation to other survey methods (i.e., pellet counts, aerial-based surveys) and in relation to an estimate of the species' abundance and spatial distribution. In general, snow-track surveys are suitable for white-tailed deer, mule deer (including Columbian black-tailed deer (*O. h. columbianus*)), elk, and moose. Additional applications may include surveying woodland caribou (*Rangifer tarandus*) in some areas and assessing mountain goat (*Oreamnos americanus*) use of forested habitat.

- Ensure project management and field survey personnel are thoroughly familiar with the relevant literature.

- Review the Wildlife Species Inventory (WSI) data standards and templates to ensure that the study design is compatible with WSI standards (http://srmwww.gov.bc.ca/wildlife/wsi/formats.htm). The WSI template can accommodate custom fields that might be required as part of the survey design.

- Obtain relevant maps and air photos of the study area. Usually 1:20,000 is the most appropriate scale.

- Consider any issues connected with access to the project area ahead of time. Determine which roads are open and available for use and which areas can be accessed by snowmobile. Helicopter access may be required in some cases and therefore must be incorporated into plans and budgets. Private land may further restrict access to winter areas – seek permission from landowners where required.

- Determine the boundary of the project area (see "Sampling Design" section).

- Determine the number, location, and length of transects (see "Sampling Design" section).

- Determine the data collection protocol and prepare standardized field cards to be used by field crews (see "Field Procedures" section).

Sampling Design

Study Area Delineation

In surveys of large areas to determine general ungulate habitat use, distribution, and relative abundance, ensure that all suitable ecological conditions within the project area are sampled. Avoid sampling areas that ungulates are unlikely to use; for example, alpine areas can be excluded from an inventory of deer during mid-winter. Defining the study area requires a combination of expert and local knowledge. The boundary of the study area may be refined as data are collected and knowledge of local populations increases. At least initially, the project area should include all possible ungulate habitats.

Project Scale

Snow-track counts are most suited to drainage-level surveys (~10,000 ha). This scale targets a wintering herd or a single population. Smaller surveys, although feasible (e.g., cut-block level) are prone to sampling errors. If a survey covers only 100 ha, random chance might dictate that no tracks are observed. Conversely, surveying an extremely large area may result in insufficient transects per unit area to capture patterns of distribution and habitat use.

Number of Transects, Locations, and Ecological Representation

The number and location of transects will depend on objectives, existing budgets, the size of the project area, and ecological variability (see “Sample Size Considerations” section).

When determining ungulate habitat use, distribution, and relative abundance for a large area, pre-stratification will provide structure and rigor to the sampling design. Pre-stratification divides the study area into ecologically similar units for sampling purposes (Krebs 1999). To illustrate, elevation and aspect strongly influence ungulate distribution, particularly in mountainous terrain. Such mountainous study areas can thus be stratified according to elevation (high versus low) and aspect (N, S, E, W) classes. In less mountainous areas, such as the boreal forest, the stratification scheme could be based on hydrology (upland, lowland) and forest cover (coniferous, deciduous, and mixed forest). Biogeoclimatic zone and snow depth can also be used to stratify a study area. The parameters chosen should reflect the local ecological conditions and should be derived from the ecological relationships of the target species.

Once the number of transects per stratum is determined, transects can be positioned randomly or systematically (Krebs 1999). In either case, transect start locations are typically chosen along access routes for greater efficiency. Start locations based on natural landscape features such as streams and habitat edges may also be used.

Generally speaking, the sampling scheme should be designed to ensure that (1) the geographic area is sufficiently covered, and (2) the ecological variability is adequately sampled.

Example: A hypothetical pre-stratification exercise for a snow-track count survey covering a large area in mountainous terrain.

The project area is 10,000 ha and is stratified using elevation (low and high) and aspect (north, south, east, west).

The area within each stratum is:

North-low = 1,500 ha	North-high = 500 ha
South-low = 2,500 ha	South-high = 1,500 ha
East-low = 1,000 ha	East-high = 1,000 ha
West-low = 1,500 ha	West-high = 500 ha

Expressed as a percentage of total area:

North-low = 15%	North-high = 5%
South-low = 25%	South-high = 15%
East-low = 10%	East-high = 10%
West-low = 15%	West-high = 5%

If the study is limited to 100 transects by budget and other logistical limitations, then the transects should be allocated as follows:

North-low = 15 transects	North-high = 5 transects
South-low = 25 transects	South-high = 15 transects
East-low = 10 transects	East-high = 10 transects
West-low = 15 transects	West-high = 5 transects

Start locations for transects are located randomly along access routes using a map themed by strata. Transects are drawn perpendicular to elevation contours or other ecological gradients within the stratum.

Pilot Studies and Local Knowledge

Depending on the local conditions, some ungulate populations congregate whereas others are dispersed. Such differences in local population behaviour are important in the scale and design of projects.

In cases where little is known about the local populations, a pilot study might be required. A pilot study using dispersed transects can help determine coarse distribution patterns. Radiotelemetry and aerial census can also be used to increase understanding of the population. At any rate, the pilot study results will enable the design of a more refined and focussed project.

Habitat Sampling

If they are needed, habitat data can be collected at the same time as snow-track counts when transect lines are short (<1000 m) and the number of track observations is low. For studies where transects are longer (>1000 m) and the frequency of track observations is high, there is often not enough time to count tracks and assess habitat. In this case, the habitat sampling could be completed during the summer months.

Due to its importance to ungulate ecology in BC and the ease with which it is sampled, snow depths should be collected on all snow-track count surveys (D'Eon 2004). Snow depth can be measured by inserting a graduated pole into the snow at regular intervals (i.e., 100 m) and/or at each track occurrence. Record the average of three probes per location.

Other Data and Analyses

Typically, habitat plots associated with track transects include some or all of the following attributes: slope, aspect, elevation, forest composition, stand age, average tree diameter, shrub abundance and composition, crown closure, and snow depth. For an overview of habitat data analyses, refer to Braun (2005). For habitat data analysis techniques specific to ungulate snow-track surveys, refer to D'Eon (2001), Poole et al. (2001), Poole and Mowat (2002a,b), Poole et al. (2003), and Serrouya and D'Eon (2002, 2003).

Recording the incidental observations of ungulate predators encountered during snow-track surveys is recommended but not mandatory.

Sample Size Considerations

The number of transects conducted is usually limited by logistical concerns such as budget and human resources. Despite this constraint, the following considerations should govern the number of required samples:

1. The expected variability among samples (e.g., a more clumped distribution requires more samples).

2. Whether the intended measure is presence/not detected or relative abundance.

3. Sampling “efficiency” (e.g., the likelihood that animal use is detected).

4. The number of contrasts to be examined with the data (e.g., relative use between early and late winter, between drainages, or between species).

In presence/ not detected studies, sampling must be sufficient to encounter at least one track per stratum. This design is rarely used for relatively common species like ungulates.

Track-count surveys generally estimate relative distribution or abundance by strata, and they estimate the significance of differences between strata. A sample unit can be either an individual track observation (for analysis of frequencies) or a length of transect, usually 100 m (for analysis of means) (D’Eon 2001). To increase the probability of detecting differences between strata, it is recommended that testing be restricted to only one effect variable (e.g., difference between years or difference between drainages, not differences between years *and* drainages).

Sample size requirements can be more rigorously determined using power analysis (Bausell and Li 2002) whereby basic assumptions about expected variation in the data and the statistical probability of detecting differences are used to estimate the needed sample size. The appropriate power analysis to use depends on the statistical test being applied. Because nonparametric and likelihood analysis methods are recommended (see “Data Analysis” below), it is best to estimate required sample sizes using techniques for standard parametric tests like two-sample *t*-tests and single-factor ANOVAs. Many resources are available to assist with power analyses, including online tools (e.g., Lenth 2006).

Sampling Effort and Timing

Because weather conditions can vary dramatically, and differences in weather severity and snow depth influence ungulate movements and spatial distribution, surveys should be performed for a minimum of 2 winters. Ideally, sampling should span several years and include periods of normal to deep snow accumulation.

In addition, the timing of fieldwork must coincide with the specific season of interest (e.g., early, mid, or late winter because many ungulate populations in BC move seasonally). If information on many seasons is required, then transects must be revisited during all seasons.

Fieldwork should also be conducted within as short a time as possible for each target season. This minimizes variation within season. For example, if snow conditions change dramatically between the start and end of a sampling period, the distribution and habitat use of ungulates may shift. The relationship between the sampling conditions and ungulate distribution will be blurred by the increased variability. Repeated, short, sampling periods within seasons increases precision of the data and improves the reliability of the distribution and of relative abundance estimates.

Personnel

Crews of two people usually perform winter transect surveys. This is a recommended safety procedure. Where safety can be assured through close proximity to others and using radio contact, one-person crews may effectively complete surveys. In all cases, Worksafe BC safety standards must be consulted and applied before permitting one-person crews to operate.

All field crew members must be:

- in good physical condition and able to travel through forested areas in winter conditions;
- familiar with methods described in D'Eon (2001);
- competent with map and compass work and able to navigate through forested terrain to locate start and end points of transects; and
- familiar with standard winter field surveying equipment, such as hip chains and snowshoes.

At least one field crew member must be:

- able to identify wildlife tracks in snow (Murie 1974; Forest 1988); and
- familiar with collecting habitat information.

Equipment

- Snowshoes
- Compass
- Hand-held GPS
- Flagging tape, marker
- Field book
- Survey forms (preferably standardized field forms specific to the project)
- Hip chain
- Snow probe (graduated pole for measuring snow depth)
- Maps
- Track identification book
- Tools involved in collecting habitat data if applicable: diameter tape, clinometer, spherical densiometer (or other device to measure crown closure; Bunnell and Vales 1990; Nuttle 1997)

Field Procedures

A two-person crew is recommended when the crew is counting tracks and also collecting habitat data. When only tracks are counted, a single person can effectively perform the transect as long as appropriate safety procedures are followed

The standard procedure for conducting an ungulate snow-track transect is as follows:

- Initiate fieldwork at least 12 hours after the most recent snowfall. Record the number of hours since last snowfall.
- Locate the Point of Commencement (POC; the predetermined starting location) for the transect, by GPS or landscape features and aerial photographs.
- In cases where roadside disturbance is significant and not representative of surrounding habitat conditions, locate the POC approximately 25–50 m from the road.
- Flag and label the POC, especially if the transect is to be revisited. Consider a permanent means of identifying the location for long studies.
- Determine the POC location with a hand-held GPS unit.
- Using a compass, and a predetermined bearing, crews begin walking in a straight line uphill. Record the predetermined bearing.
- Record the species, the location of each ungulate track crossing the transect and the number of crossings in the case of multiple individuals or tracks. Trails are obvious travel routes where individual tracks are indistinguishable. Trails are recorded as “Trails” and are treated differently during data analysis (see “Data Management Considerations” section).
- Use a hand-held GPS or a hip chain measurement from the POC to determine the location of each track or trail (see “GPS Measurements” section below).
- Sample snow depth at regular intervals along the transect or at each track occurrence.
- Record all ungulate tracks until the end of the transect is reached. The end of the transect also should be recorded.
- Collect any habitat data at plots placed systematically along the transect (see “Habitat Sampling” section above).
- Transect length varies depending on terrain, logistical issues, and whether habitat information is being collected. In mountainous terrain, 1000-m transects are consistently achievable. In flatter terrain, 2000-m transects are feasible.

These field procedures describe the standard procedure for field crews walking through forested areas on foot (snowshoes). It is also possible to use snowmobiles to greatly increase transect length in appropriate terrain (Fiera Biological Consulting Ltd. 2005).

GPS Measurements

GPS locations are required for transect start and end points. When feasible, locations in the field should also be recorded using GPS. In heavily forested areas juxtaposed with steep terrain and narrow valleys, however, GPS units often fail to acquire positions. Repeated GPS measurements along transects in such areas may be cumbersome, or even impossible. In these situations, locations along the transects can be calculated from hip chain measurements and slope gradient.

Safety Issues

Winter transect surveys occur in isolated areas during winter and often require snowmobile access. The fieldwork is physically demanding and the terrain may be rugged and potentially dangerous. Avalanche hazards exist in mountainous areas.

To address these safety concerns and successfully complete surveys, field crews must be:

- experienced field/forest workers;
- trained or knowledgeable in winter survival and first aid;
- trained or knowledgeable in snowmobile use and handling;
- provided with radios and/or other communication devices;
- physically fit and able to work under adverse field conditions; and
- trained or knowledgeable in avalanche awareness and rescue (if applicable).

Data Management Considerations

A collection of many tracks is recorded as a "trail" by field crews. When the number of tracks cannot be determined, treat a trail as the equivalent of a predetermined number of tracks (e.g., 5), consistent with Thompson et al. (1989).

The time between snowfalls can influence the number of tracks observed and bias results. In most cases, the longer the time between snowfalls, the higher the track count, since the ungulates have more time to move around. As a result, it is important to standardize track counts to account for differences in the time since the last snowfall. To do so, divide the number of tracks by the number of days since the last snowfall. For example, if 12 tracks are counted and 2 days have passed since the last snowfall, the standardized track count for that transect is 6.

For analyzing species habitat relationships, track counts occurring on either side of a habitat plot are considered to be associated with the plot. For example, if habitat plots are performed every 100 m, then tracks within 50 m on either side of the plot centrums are associated with that plot.

Data Analysis

Track counts are not normally distributed. The total counts of most transects or transect segments are usually low, and samples containing large numbers of tracks are rare. Because of this, statistical analysis of track count data using parametric tests is problematic. The assumptions required by a given statistical test must be well understood and considered in order to justify the use of the test.

Nonparametric equivalents of common parametric tests are preferred. For example, the Mann-Whitney U-test may be used to compare years within the same area or between two areas. The Kruskal-Wallis test is a nonparametric ANOVA for comparing more than two samples. Post-hoc pairwise comparisons can be made using a variety of methods, most commonly the Tukey test (Zar 1998). Chi-square tests are another alternative.

The principal drawback of nonparametric methods is that they are considerably less powerful than their parametric equivalents. This means that larger samples are required to detect differences between strata.

Simple frequencies of tracks (rather than tracks per segment transect) can be analyzed using contingency tables or log-linear techniques (Zar 1998). These procedures are particularly useful for analyzing habitat relationships.

Where more robust methods are required, the likelihood-ratio testing techniques developed by White and Bennetts (1996) are recommended. Their method first tests the goodness-of-fit of observations to a negative binomial distribution and then compares alternative models to test hypotheses related to differences in means between areas or years. A biologist who does not have a strong statistical background is encouraged to consult a statistician before applying these relatively sophisticated methods.

Another statistical issue that is more difficult to address is the fact that transect surveys result in data that are correlated in space and time. The only solution to this statistical dilemma is to establish completely randomized transect segments and associated habitat plots throughout a project area. However, this design is almost always impractical. Rather, researchers should be aware of the concern and address it when and where possible (see Alldredge and Ratti 1986; D’Eon 2001).

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