MONITORING THE EFFECTIVENESS OF UNGULATE WINTER RANGES ESTABLISHED FOR MOUNTAIN GOATS: ESTABLISHING MONITORING PROTOCOLS AND ECOLOGICAL BASELINES

PREPARED BY
Steven F. Wilson, Ph.D., R.P.Bio.

PREPARED FOR
Forest Practices Branch, BC Ministry of Forest and Range
8th Floor, 727 Fisgard Street, Victoria, BC V8W 1R8

15 March 2006
Executive Summary

Mountain goats (*Oreamnos americanus*) are a relatively common resident of British Columbia’s most rugged habitats. BC has a significant responsibility for conservation of mountain goats because >50% of the world’s population occurs in the Province. The winter season is considered a critical period due to nutritional deprivation and high energy expenditure related to thermoregulation and mobility in snow. As a result, the Province is legally establishing *ungulate winter ranges* to provide critical life requisites for wintering mountain goats.

Here I develop monitoring protocols and ecological baselines associated with effectiveness indicators proposed by a previous project. I develop both office and field procedures for monitoring and present results of a pilot implementation of the field procedures in two pilot areas.

I established two pilot project areas, one for interior ecotype mountain goats and the second for coastal ecotype goats. The interior site was Foxy Canyon, located in the Lakes Forest District, 35 km southeast of Houston, as well as the nearby Dungate Creek bluffs winter range area. The coastal site was Howe Sound, located in the Sunshine Coast Forest District, approximately 20 km southwest of the town of Squamish.

Field procedures were piloted in Foxy Canyon on 23 February 2006, Dungate Creek on 24 February 2006, and in McNab Creek in Howe Sound on 23 March 2006. Data were collected at 15 field plots in total. The following summarizes results for the different indicators:

1. **Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range**: Measuring this indicator is a routine office procedure and was not completed for this study; however, there are practical limitations to completing the analysis that might be relevant to other areas. In coastal areas where some winter ranges have been “grandparented” for many years, the original rationale for areas, with respect to either biology or policy might not be obvious. In other areas where winter ranges have been mapped more recently, there is usually an independent biology-based map, often generated by a habitat model, and then verified through further investigation. In these situations, the proportion of suitable or capable winter range habitat under management can be calculated.

2. **Forest Cover Characteristics**: Results of the pilot monitoring suggest that characterizing forest cover should focus on quantifying blowdown and forest health issues, as well as canopy closure estimates within field plots.

3. **Evidence of Movement Among Winter Ranges**: For the Foxy Canyon and Dungate Creek pilot areas, GPS telemetry data of mountain goats from two recent winters suggested that mountain goat movements were largely restricted to a single winter range area, although there was evidence of mountain goat movements between winter ranges in consecutive winters.

Monitoring movement among winter ranges will be difficult in many areas because telemetry data are rare and most studies are conducted for only a few years. Direct observations of tracks on aerial survey flights provide anecdotal information at best, because tracks are visible only in unforested areas. Even where winter ranges are separated by expanses of unforested habitat, movements are still difficult to detect because mountain goats can remain on specific winter ranges for long periods and move to different areas only infrequently.

4. **Forage Availability**: Evidence of feeding by mountain goats was found within only one plot at Dungate Creek bluffs where goats had been cratering for ground forage at an exposed site. In addition, “long-lining” tracks resulted in evidence of feeding on subalpine fir (*Abies lasiocarpa*) blowdown in a group selection site. Shrub cover was variable but evidence of feeding was not detected, nor was feeding on the sparse lichen litterfall evident. I found evidence of
browse throughout the area surveyed in the Howe Sound pilot area; however, use could not be identified to species because the area was also used extensively by wintering black-tailed deer (*Odocoileus hemionus columbianus*).

Because definitely evidence of feeding was relatively rare, and because mountain goats have varied diets that depend largely on availability (Laundré 1994), monitoring forage availability might not be particularly useful.

5. **Snow Depth and Consolidation**: Snow at Foxy Creek habitat plots was 23-62 cm (n = 7) deep and depths were correlated with percent crown closure. Sinking depths were 13-23 cm (n = 7) and did not change significantly with changes in crown closure. Sinking depths of tracks observed in plots were 10-25 cm (n = 4). Snow depths in plots where mountain goat tracks were observed were <40 cm at Foxy Creek (n = 3), while plots where tracks were not observed all had snow depths exceeding 40 cm (n = 4). In contrast, the low elevation portions of the winter range surveyed in the Howe Sound pilot area had very limited snow cover. Without forest canopy there were intermittent snow patches at 432 m elevation and >1 m deep snow at 774 m. Although there were no tracks in the deep snow at 774 m, there were tracks sinking 10 cm under forest canopy.

Maintaining high canopy closure in order to reduce snow depths on the ground in areas surrounding escape terrain results in the principal timber supply impact to the forest industry. Characterizing and monitoring this relationship is therefore an importance focus of effectiveness monitoring. These data are also relatively easy to collect during ground-sampling and to analyze.

6. **Evidence of Sustained Winter Use**: In areas of low or non-existent forest canopy, evidence of use was easy to confirm in the pilot project areas through direct observation of tracks during reconnaissance-level aerial surveys. Similarly, evidence of use was relatively easy to confirm on the ground under the forest canopy, although the ability to identify tracks, pellets and browse to species will depend on snow conditions and spatial overlap with other ungulates.

In general, field methods were practical, although the ability to navigate steep or broken terrain will limit field sampling in many areas. Now that many of the indicator methods have been tested and refined, the next step is to develop an implementation plan that includes:

1. Roles and responsibilities for collecting, analyzing and warehousing data;
2. A mechanism for approving and documenting required changes to management when unacceptable outcomes are encountered; and,
3. Office and field manuals that concisely present for practitioners the monitoring protocols, data capture requirements and analysis methods.

Effectiveness monitoring is a key task in the adaptive management process. Extensive monitoring will increase the overall robustness of mountain goat management by examining the full range of suitable ecological conditions and appropriate practices. As a result, management can move beyond attempting to achieve to a single optimum condition and can instead focus on managing to a range of acceptable outcomes using a more extensive policy and practices “toolbox”.
# Table of Contents

Cover photo: nanny and kid on winter range in Bute Inlet, March 2001 by Steve Gordon

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgments</td>
<td>5</td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Methods</td>
<td>1</td>
</tr>
<tr>
<td>Pilot Project Areas</td>
<td>1</td>
</tr>
<tr>
<td>Monitoring Protocols</td>
<td>1</td>
</tr>
<tr>
<td>Ecological Baselines</td>
<td>3</td>
</tr>
<tr>
<td>Results</td>
<td>3</td>
</tr>
<tr>
<td>Pilot Project Areas</td>
<td>3</td>
</tr>
<tr>
<td>Foxy Canyon-Dungate Creek</td>
<td>3</td>
</tr>
<tr>
<td>Howe Sound</td>
<td>4</td>
</tr>
<tr>
<td>Monitoring Protocol Methods</td>
<td>5</td>
</tr>
<tr>
<td>1. Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range</td>
<td>5</td>
</tr>
<tr>
<td>2. Forest Cover Characteristics</td>
<td>5</td>
</tr>
<tr>
<td>3. Evidence of Movement Among Winter Ranges</td>
<td>7</td>
</tr>
<tr>
<td>4. Forage Availability</td>
<td>7</td>
</tr>
<tr>
<td>5. Snow Depth and Consolidation</td>
<td>8</td>
</tr>
<tr>
<td>6. Evidence of Sustained Winter Use</td>
<td>8</td>
</tr>
<tr>
<td>7. Winter Range Field Sampling Procedures</td>
<td>9</td>
</tr>
<tr>
<td>8. Data Capture</td>
<td>11</td>
</tr>
<tr>
<td>9. Data Analysis</td>
<td>11</td>
</tr>
<tr>
<td>Results of Pilot Monitoring</td>
<td>11</td>
</tr>
<tr>
<td>1. Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range</td>
<td>12</td>
</tr>
<tr>
<td>1a. Ecological Baseline for Suitable/Capable Habitat</td>
<td>12</td>
</tr>
</tbody>
</table>
2. Forest Cover Characteristics
   2a. Ecological Baseline for Forest Cover Characteristics
3. Evidence of Movement Among Winter Ranges
4. Forage Availability
   4a. Ecological Baselines for Forage Availability
5. Snow Depth and Consolidation
   5a. Ecological Baselines for Snow Depth and Consolidation
6. Evidence of Sustained Winter Use
   6a. Ecological Baselines for Sustained Winter Use

Discussion

Pilot Project Areas
Monitoring Protocols
1. Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range
2. Forest Cover Characteristics
3. Evidence of Movement Among Winter Ranges
4. Forage Availability
5. Snow Depth and Consolidation
6. Evidence of Sustained Winter Use

Adaptive Management

Conclusions and Management Recommendations

Literature Cited

Appendix I

Appendix II
Acknowledgments

I would like to thank Laurence Turney (Ardea Biological Consulting, Smithers) for providing advice and data related to the Foxy Canyon and Dungate Creek winter range areas. Laurence and Steve Gordon (BC Ministry of Environment, Smithers) assisted with fieldwork. Darryl Reynolds (BC Ministry of Environment, Sechelt) and Steve Gordon provided advice and data related to the Howe Sound winter ranges. Greg Ferguson assisted with fieldwork. Greg George (BC Ministry of Environment, Surrey) and Pierre Johnstone (BC Ministry of Environment, Fort St. John) made helpful comments on an earlier draft. This project was administered by Wayne Erickson (BC Ministry of Forests and Range, Victoria).
Introduction

British Columbia has a significant responsibility for managing mountain goats (*Oreamnos americanus*) because >50% of the world’s population resides in the Province (Shackleton 1999). The winter season is considered a critical period for mountain goats due to nutritional deprivation and high energy expenditure related to thermoregulation and mobility in snow (Wilson 2005a). As a result, the Forest and Range Practices Act (FRPA) allows for legal designation of mountain goat winter ranges under Section 12 of the Government Actions Regulation.

Wilson (2005a) identified a suite of indicators in relation to key monitoring questions that could be used to monitor the effectiveness of mountain goat habitat management under the FRPA. The next steps in developing an effectiveness monitoring programme are to develop protocols based on the suite of indicators, to establish ecological baselines, and to test the methods in pilot project areas.

In this report I develop both office and field procedures for monitoring and present the results of a pilot implementation of the field procedures in two project areas.

Methods

Pilot Project Areas

Regional agency staff, forest industry biologists and mountain goat biologists were consulted to identify candidate pilot areas in BC. Necessary requirements for pilot project area(s) included:

- Cooperative licensees;
- Established or proposed mountain goat winter ranges; and,
- A relatively high density of mountain goats.

Desirable features included:

- Licensees undertaking work in 2005-6 related to establishing or managing mountain goat winter ranges;
- Areas with planned mountain goat inventory activities in 2005-6;
- Winter ranges accessible from the ground;
- Pilot areas on the coast and in the interior to capture the habitat requirements of different mountain goat ecotypes (Hebert and Turnbull 1977); and,
- Areas where mountain goats have been, or are currently, radio-collared.

Monitoring Protocols

I stratified proposed indicators developed by Wilson (2005a) by required monitoring intensity: routine, extensive and intensive (Table 1). Routine indicators are generally monitored through office procedures while extensive indicators require some field reconnaissance. Intensive indicators require additional effort to collect specific quantitative information. Because of the resources required, monitoring some intensive indicators generally requires collaboration with other research or inventory projects.
Table 1. Recommended indicators, levels of intensity, results and minimum monitoring frequencies for ungulate winter ranges established for mountain goats, from Wilson (2005a).

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>LEVEL OF INTENSITY</th>
<th>DESIRED CONDITION / RESULT</th>
<th>MINIMUM MONITORING FREQUENCY</th>
<th>RATIONALE AND COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of area in established Ungulate Winter Range relative to available suitable winter range habitat</td>
<td>Routine</td>
<td>All suitable and occupied winter ranges protected / all capable winter ranges protected (depending on management objective)</td>
<td>Once when winter ranges are being legally established</td>
<td>All suitable and occupied winter range habitat should be within boundaries of established Ungulate Winter Range or otherwise protected if the management objective is population maintenance. Additional habitat should be protected if the objective is to recover the local population.</td>
</tr>
<tr>
<td>Forest cover characteristics</td>
<td>Extensive</td>
<td>Contiguous old forest on ranges below tree line except for small openings associated with rock outcrops</td>
<td>Every 5 years</td>
<td>Forest cover is susceptible to blow-down, senescence of veteran trees and salvage (where allowed). Aerial or ground-based assessments are required.</td>
</tr>
<tr>
<td>Forage availability</td>
<td>Extensive</td>
<td>Abundant and available preferred rooted forage and litterfall</td>
<td>Every 5 years</td>
<td>Requires qualitative ground assessments. Forage availability is influenced by growing conditions for rooted forage, forest canopy characteristics (amount and characteristics of litterfall – particularly Douglas-fir and lichen), and snow interception characteristics – shallower snow provides better access to available forage. Quantitative forage assessments could also be considered.</td>
</tr>
<tr>
<td>Snow depth and consolidation</td>
<td>Intensive</td>
<td>Shallow snows that do not affect the mobility of mountain goats or access to available, preferred forage</td>
<td>Depends on the frequency of severe winter conditions</td>
<td>The importance of winter ranges increases with winter severity; therefore, snow conditions should be assessed during average and severe winter conditions. General qualitative assessments can be made from the air or on the ground, but quantitative assessments, requiring ground reconnaissance (e.g., actual snow depth and sinking depth measures), are recommended.</td>
</tr>
<tr>
<td>Evidence of sustained winter use by mountain goats</td>
<td>Routine</td>
<td>Observations of mountain goats in designated UWR by commercial backcountry recreation operators</td>
<td>Annually</td>
<td>Commercial backcountry tenure holders are usually required to report wildlife sightings. These data can be used to determine occupancy of some winter ranges, although data will be incomplete and quality will vary. Information from other backcountry users can be gathered on an ad hoc basis.</td>
</tr>
<tr>
<td>Evidence of sustained winter use by mountain goats</td>
<td>Extensive</td>
<td>Evidence of browse, presence of pellet groups, tracks, direct observations</td>
<td>Every 3 years</td>
<td>Requires aerial surveys or ground reconnaissance.</td>
</tr>
</tbody>
</table>
Evidence of movement among winter range areas | Intensive | Telemetry locations indicating movement among winter range areas through different habitat conditions | In cooperation with research or inventory projects | Relocation frequency must be high to capture movements between winter ranges. Some information can also be inferred from track observations on winter survey flights, although this will be incomplete.

The scope of this project included developing monitoring protocols for the mountain goat winter range indicators described in Wilson (2005a). Protocols include:

1. Detailed methods regarding collection, analysis and warehousing of indicator data; and,
2. An adaptive management system for updating management practices based on monitoring results.

Resource Information Standards Committee methods were used wherever possible.

Although I developed methods for all indicators, the focus of this project was to pilot the implementation of extensive and intensive (where possible) monitoring protocols in the field. Results related to the implementation of office procedures are reported where indicator data were available.

Ecological Baselines

Ecological baselines represent the benchmarks that indicators are measured against to indicate trends in ecological conditions. Wilson (2005) provided broad “desired conditions” for each potential indicator. Some of these desired conditions provide obvious baselines while other indicators needed to have baselines established. Baselines are generally unavailable in the literature and needed to be inferred from measures of current conditions. These current conditions were determined from field investigations on the pilot project areas, where extensive and intensive indicator data were collected.

Results

Pilot Project Areas

Two pilot project areas were established, one for interior ecotype mountain goats and the second for coastal ecotype goats.

Foxy Canyon-Dungate Creek

Foxy Canyon is located in the Lakes Forest District, 35 km southeast of Houston (Figure 1). A continuous section of canyon extends for approximately 13 km at depths of 50-150 m along Foxy Creek. The canyon is entirely within the SB5mc2 biogeoclimatic subzone variant (Banner et al. 1993) and consists of discontinuous bedrock cliffs and steep forested slopes. Much of the canyon is mapped as mountain goat winter range (Figure 2; R. Heinrichs, pers. comm.) The canyon supports a minimum populations of 37 goats (as of September 2000), with use concentrated near the canyon rim (Turney et al. 2001, Mahon and Turney 2002).
Twenty-seven mountain goats were radio-collared (8 GPS and 19 VHF) in Foxy Canyon and nearby Morice Moutain, Bob Creek Bluffs, Dungate Creek Bluffs, China Nose and Klo Creek Bluffs in January and March 2003 (Turney and Roberts 2004, Turney 2005). Some collars were still active in winter 2005-6 (L. Turney, pers. comm.).

Dungate Creek Bluffs are located approximately 20 km west of Foxy Canyon. The area is consists of bedrock cliffs and a plateau of subalpine forest. The area is within the ESSFmc biogeoclimatic subzone (Banner et al. 1993).

Howe Sound

The Howe Sound winter ranges are located in the Sunshine Coast Forest District, approximately 20 km southwest of the town of Squamish (Figure 3). There are several proposed Ungulate Winter Ranges for mountain goats located in the Rainy, McNab and Potlatch Creek drainages. Most are on warm aspects that extend from lower elevations in the CWHdm and CWHvm1 biogeoclimatic subzone variants, up through the CWHvm2, MHmm1 and into ATunp ecosystems (Figure 4; Green and Klinka 1994).
The pilot area is within BC Timber Sales, Strait of Georgia Business Area. Although Interfor led a GPS telemetry study of mountain goats during 2001-3 on the Sunshine Coast, no mountain goats were collared in this area (Taylor et al. 2004).

Monitoring Protocol Methods

1. Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range

Determining the proportion suitable and/or capable habitat within an area of interest (AOI) that is protected and/or managed as mountain goat winter range is an office procedure that depends on availability of the following data:

- Maps of ungulate winter range boundaries and other constrained areas such as parks and protected areas, Old Growth Management Areas, Wildlife Habitat Areas, etc.; and,
- Maps of all suitable or capable mountain goat winter range.

Maps of all suitable or capable mountain goat winter range can be derived using a variety of methods (Wilson 2005b). A systematic aerial inventory (e.g., Rochetta 2002) provides the opportunity to characterize both fine-scale habitat characteristics as well as the presence of mountain goats. Habitat models have also been used to identify “potential” winter range areas based on topographic and forest cover characteristics (e.g., Gross et al. 2002, Heinemeyer et al. 2003). However, these models typically over-estimate the availability of suitable winter ranges and reconnaissance to confirm habitat characteristics and occupancy by goats is still necessary. Also, the detailed terrain characteristics of microsites used by wintering goats cannot be resolved by available mapping (e.g., Jex 2004). A blend of methods using maps, aerial photo interpretation and survey flights is also an option (e.g., Pollard 2002, Dunsworth 2004).

Areas managed as goat winter ranges include mapped ungulate winter ranges and other areas of suitable or capable mountain goat habitat that are otherwise constrained. The analysis of suitable and/or capable habitat should be conducted when ungulate winter ranges are being proposed and should be included in associated reporting. Responsibility for the analysis rests with the authors of ungulate winter range plans, which varies depending on whether the AOI is a TSA or TFL, etc.

Analysis Procedures: This involves a simple GIS area comparison between the final mountain goat habitat map and the final policy map illustrating legal ungulate winter ranges.

2. Forest Cover Characteristics

Forest cover is an important characteristic of some mountain goat winter ranges; particularly in coastal regions where deep, unconsolidated snow forces mountain goats to elevations below tree line where dense canopies intercept snow.
fall and reduce snow depths on the ground (Wilson 2005b). Ensuring that forest canopy conditions are sufficient to moderate snow depths on winter ranges, and ensuring that canopy conditions persist over the long-term, are the reasons for monitoring forest cover characteristics. The focus of the monitoring is on forested buffers surrounding suitable escape terrain, because there are outstanding questions related to the required extent of forested buffers (both in terms of snow interception cover and buffers from disturbance). Although trees associated with escape terrain are important features on some ranges (e.g., in coastal areas), these trees are usually not threatened by harvest plans and it is generally too dangerous to assess such areas on the ground.

Office Procedures: Evidence of blowdown or forest health issues can be assessed either qualitatively or quantitatively by comparing digital orthophotos taken at different times.

Field Procedures: Blowdown and forest health can be further assessed during reconnaissance flights and additionally during field sampling. Office pre-work and field procedures are presented below for winter range field sampling.
Evidence of Movement Among Winter Ranges

Although winter ranges are being legally established, there is no legal framework for ensuring the effectiveness of ranges in a landscape context. Although some mountain goats remain within areas smaller than most established winter ranges for large parts of the season, more typically animals move between patches of suitable habitat (Taylor et al. 2004). As a result, it is important that forest harvesting activities occurring in areas between ranges do not interfere with movements of mountain goats between ranges. However, there has been little research on the effects of harvesting on movement of mountain goats between winter ranges.

Given the absence of data related to winter movements through different habitats between patches of suitable winter habitat, it is important to document such movements wherever possible.

Office Procedures: Movements between winter range areas can be documented through office procedures where telemetry location databases exist. These databases are unlikely to provide information on travel routes but can confirm that goats are travelling between winter ranges.

Field Procedures: Mountain goat tracks are often observed on winter reconnaissance flights. Tracks of mountain goats are usually distinguished from those of other ungulates by the terrain in which they are found. Tracks are usually observed in areas above treeline and provide limited information on use of the forest matrix existing between winter ranges areas. Although tracks can be inventoried during fieldwork (see procedures below), it is impractical to use fieldwork to confirm travel between winter ranges because of the area involved.

Forage Availability

Mountain goats are generalist herbivores and have varied diets (Laundré 1994). The characteristics of the forest understorey determine the availability of forage for wintering mountain goats. Goats in coastal ranges subsist on forbs, ferns, conifers, lichens and mosses (Hjeljord 1973). As snow depths increase, the proportion of forbs and ferns in the diet declines (Fox and Smith 1988). At snow depths of >50 cm, forbs and ferns become unavailable and goats forage on conifer leaves and lichens from standing trees and litterfall, and on mosses from substrates not covered by snow (Fox and Smith 1988). Older forests are generally associated with more abundant arboreal lichens and litterfall (Rochetta 2002). In interior regions where snow depths on high-elevation, windswept winter ranges are shallow, winter diets of mountain goats are dominated by grasses and shrubs (Laundré 1994).
Documenting the relative availability of forage within winter ranges is an important component of determining effectiveness. In general, ranges with adequate forage are expected to have tall and vigorous shrub growth above the snow line and abundant litterfall for periods of deep snow fall.

**Office Procedures:** There are no office procedures available for assessing forage availability on mountain goat winter ranges because aerial photos or other remotely assessed data do not provide information on forage availability under the forest canopy.

**Field Procedures:** Office pre-work and field procedures are presented below for winter range field sampling.

### 5. Snow Depth and Consolidation

Mountain goat winter ranges are characterized by features that moderate snow depths. This allows goats adequate mobility while minimizing their energy expenditure. Interior mountain goat populations tend to winter at high elevations on windswept south and southwest-facing slopes, but heavy snow loads in coastal mountains force goats to move to low elevation areas in search of food sources not buried by deep snow (Fox and Smith 1988, Fox et al. 1989, Shackleton 1999). Mountain goats in the Cascades have habitat use characteristics intermediate between coastal and interior ecotypes (Gilbert and Raedeke 1992).

Objectives for ungulate winter ranges managed for mountain goats usually emphasize the retention of forest canopy to intercept snow; therefore, the focus of monitoring should be on whether the forest characteristics on the winter range are sufficient to moderate snow depth to an extent that mobility of mountain goats within the winter range is higher than areas outside the winter range.

Snow depths vary considerably within and between years. As a result, a key measure of the moderating effects of winter range characteristics is the difference between snow depths in open reference areas and that under canopy within the boundaries of the winter range. Snow depth is not the only factor affecting mobility of mountain goats - snow consolidation is also an important consideration which can vary considerably with snowfall patterns, freeze-thaw dynamics and other variables.

**Office Procedures:** Although snow depths can be qualitatively assessed via aerial reconnaissance, ground assessments provide the best data.

**Field Procedures:** Office pre-work and field procedures are presented below for winter range field sampling.

### 6. Evidence of Sustained Winter Use

Evidence of consistent winter use by mountain goats over many years is the most important indicator of the effectiveness of winter ranges areas established for mountain goats.

**Office Procedures:** Commercial backcountry recreation tenure holders are required to report anecdotal wildlife sightings. Some also contract annual censuses of mountain goats within their tenure areas. These data can be used to indicate sustained use of winter ranges established for mountain goats. The value of anecdotal sightings will be limited because tenure holders are encouraged to use flightpaths that avoid occupied winter ranges. In future, similar data might become available from other resource users (e.g., oil and gas exploration activities) and can be used in a similar manner.

Where local mountain goat populations are being monitored by telemetry, use of winter ranges can be determined through analysis of point location data. These analyses will under-estimate actual use because only a small and un-
representative sample of the population is usually radio-collared. Telemetry data can confirm occupancy but it cannot establish whether winter ranges have been abandoned.

**Office Procedures:** Point location data can be plotted in relation to winter range boundaries in a GIS. Movements between winter ranges can be determined by examining point data for individual animals.

**Field Procedures:** Winter aerial inventory surveys (RIC 2002) are most commonly used to establish occupancy of mountain goat winter ranges, but goats are frequently missed on flights. Ground surveys are more reliable but are impractical to conduct on every winter range. Office pre-work and field procedures are presented below for winter range field sampling.

### 7. Winter Range Field Sampling Procedures

Collection of field data related to forage availability, snow depth and consolidation and evidence of use can be collected in aggregate using the procedures below:

**Office Pre-work:**

Candidate winter ranges for sampling should be determined from all available information, including recent aerial photos/digital orthophotos. Mountain goats live in steep and often treacherous terrain and many areas can not be accessed safely, particularly in winter. Safely is the primary concern in all field sampling. It might not be obvious from photos whether winter ranges can be navigated safely and local knowledge should be canvassed before selecting a winter range for sampling. As mentioned previously, the focus of the field monitoring is the forested buffers that surround suitable escape terrain, rather than the escape terrain itself. These forested areas are generally safer for surveyors to traverse but the safety of forested areas can not be assumed.

The number of winter ranges to be sampled depends on available resources and the costs associated with conducting fieldwork (e.g., helicopter transit costs). Winter ranges with recent clearcuts along at least one edge are useful for sampling because they provide an opportunity to assess any blowdown affects and also provide good reference points for assessing snow depths.

Identify possible points of origin on maps for transect sampling. Ideal locations are in clearcuts near the winter range boundary on shallow slopes and on an aspect similar to most of the winter range. Points should permit transects to be navigated at approximately 45 degrees up or downslope, if practicable. More than one point of origin can be identified if resources allow for more extensive sampling.

**Required equipment:** graduated pole for measuring snow depth, graduated ski pole with basket for measuring consolidation (or preferably a ram penetrometer if available), tape measure, flagging tape, tree markers, GPS, clinometer, compass, camera, MELP and MOF (1998), MOF (1992), field cards (suggested cards in Appendices I and II; most fields are Resources Information Standards Committee fields also available on FS882(1) and FS882(5) [MELP and MOF 1998]).

**Field sampling:**

1. Navigate to point of origin and select area for plot approximately 20 m from winter range boundary with no forest overstorey, if possible. Record plot data (Table 2).
Table 2. Data to be collected at each plot along winter range transects. Data are used to monitoring the effectiveness of winter range areas established for mountain goats.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>VARIABLES</th>
<th>METHODOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot context</td>
<td>Site characteristics</td>
<td>Estimate slope with clinometer, aspect with compass, elevation from altimeter or GPS; UTMs from GPS, take photograph. Record other site characteristics from Appendix I according to methods in MELP and MOF (1998)</td>
</tr>
<tr>
<td>Snow depth and consolidation</td>
<td>Snow depth</td>
<td>Measure to nearest 5 cm with graduated pole at 10 locations within 20 x 20 m plot; note depth of crust layers (Appendix II)</td>
</tr>
<tr>
<td></td>
<td>Snow consolidation</td>
<td>Sink graduated ski pole into snow using strength of one arm, record sinking depth to nearest 5 cm at 10 locations within 20 x 20 m plot (Appendix II)</td>
</tr>
<tr>
<td>Forest cover characteristics</td>
<td>Forest Canopy</td>
<td>Percent cover for tree layer, dominant species in A1, A2 and A3 layers within 20 x 20 m plot (Appendix I; MELP and MOF 1998)</td>
</tr>
<tr>
<td>Forage availability</td>
<td>Shrub, herb and moss abundance</td>
<td>Percent cover for shrub, herb and moss layers above the snow line, including dominant shrubs in B1 and B2 layers within 20 x 20 m plot (Appendix I; MELP and MOF 1998)</td>
</tr>
<tr>
<td></td>
<td>Lichen/Litterfall</td>
<td>Plot estimate of lichen abundance (MOF 1992), qualitative assessment of lichen-bearing branch litterfall within 20 x 20 m plot</td>
</tr>
<tr>
<td>Evidence of use by mountain goats</td>
<td>Visible sign</td>
<td>Record all tracks (and sinking depth), pellets, hair, etc. evident in the 20 x 20 m plot according to methods in MELP and MOF (1998)</td>
</tr>
</tbody>
</table>

2. Follow mountain goat tracks to look for evidence of browse, beds, hair, etc. Effort spent “long-lining” tracks depends on the abundance of tracks and time available.
3. If areas of intense use (see below) by goats are encountered (e.g., large pellet concentrations and hair, often on rocky outcrops with little or snow cover), note GPS location and take photographs. Mark the area with paint blazes and a tree marker and make detailed notes of the location to ensure that future surveyors can find the area.

4. Return to the plot location and take a bearing that traverses the winter range at an approximate 45 degree angle (either upslope or downslope, depending on point of origin, if possible). Establish next plot 20 m inside winter range boundary and repeat steps 1-3.

4. Continue establishing plots at either 20 or 50 m intervals, depending on the size of the winter range and the feasibility of navigating along the transect line. The objective should be to capture data at at least 5 plots along the transect within the winter range boundary.

Areas of intense use can be further monitored by clearing pellets from small plots (e.g., 1 m²) at the beginning of the winter and returning in the spring to assess use. Pellets can be dried and weighed, counted or simply photographed to assess relative use.

8. Data Capture

Data should be captured in the relevant standard database (Venus 5.0; srmwww.gov.bc.ca/ecology/dteif/venus.html). Additional data (e.g., snow data) should be provided in a standard spreadsheet format with complete metadata.

9. Data Analysis

Most the monitoring data require only summary statistics and qualitative comparisons. The exceptions are data related to snow and sinking depths, crown closure and pellet removal plots. The relationship between snow and sinking depths and canopy characteristics can be explored using regression analyses by forest type. Relative use of intensive use sites, as measured at pellet removal plots, can be compared among years using frequency analyses if pellets are counted (e.g., chi-squared or g-tests, or log-linear analyses where additional variables are considered), or comparisons among means (t-tests, ANOVA) where pellets are weighed and data are available for several sites and/or years.

For analysis of telemetry data there are a variety of techniques that can visually illustrate evidence of movement among winter ranges. For this project I illustrated the spatial relationship among telemetry locations by generating a “spanning tree” by mountain goat and year. Spanning trees do not connect consecutive locations but rather create a network of points based on minimum Euclidean distances without loops. The resulting network is relatively simple to interpret for the purposes of assessing movements among winter ranges.

Results of Pilot Monitoring

Field procedures were piloted in two locations within the Foxy Canyon winter range area on 23 February 2006, as well as on the nearby Dungate Creek winter range on 24 February 2006. Data were collected at 10 field plots in total. Within the Howe Sound pilot area, one winter range in McNab Creek was investigated and data at 5 plots were collected (4 within the CWHvm1 and 1 within the CWHvm2 biogeoclimatic variants). Sampling transects did not follow a 45-degree angle upslope during any of the surveys because: 1) at Foxy Canyon and Dungate slopes were gentle and variable; and, 2) in Howe Sound slopes were very steep (often >80%) and progress was governed by navigable terrain.
1. Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range

Measuring this indicator is a routine office procedure and was not completed for this study; however, there were also practical limitations to completing the analysis that might be relevant to other areas.

For the Foxy Canyon-Dungate Creek pilot area, linework was still being negotiated on the basis of a preliminary habitat model (R. Heinrichs, pers. comm., Turney 2004). The habitat model also required some revision (L. Turney, pers. comm.). Once the linework is final and the habitat model revised, an analysis comparing suitable/capable habitat to negotiated UWR can be completed.

Goat winter ranges in Howe Sound are part of the Sunshine Coast ungulate winter range plan. The plan was yet to be approved, so the final policy layer was not available. However, the evolution of the plan made determining the differences between the biological rationale and the policy rationale difficult. The map of winter ranges had undergone many revisions, based both on improving biological knowledge and on negotiations with licensees. At no point was a final biological map of winter ranges independently prepared and then negotiated into a final policy layer.

1a. Ecological Baseline for Suitable/Capable Habitat

There is no ecological baseline associated with the proportion of suitable/capable habitat managed as mountain goat winter range; rather, this statistic provides a management baseline that reflects the landscape-level potential for managing and protecting mountain goat winter range. The goal of capturing all winter ranges in UWR or other constrained areas can be justified by the relative paucity of suitable and/or capable winter habitat for mountain goats.

2. Forest Cover Characteristics

There are two objectives related to monitoring forest cover characteristics: 1) to ensure that the forest characteristics that the winter range was established to protect persist over time; and, 2) to ensure that the forest canopy has the necessary characteristics to reduce snow depths on the ground. Procedures related to the first objective are either office-based or require extensive aerial inventory, both of which were beyond the scope of this pilot project. The second objective is closely related to the snow monitoring component and is addressed (with ecological baselines) in the relevant sections below.

2a. Ecological Baseline for Forest Cover Characteristics

The forest characteristics of the winter range at the time of legal establishment form the ecological baseline against which future monitoring results should be assessed, unless recovery of forest characteristics is an objective for the winter range.

3. Evidence of Movement Among Winter Ranges

For the Foxy Canyon and Dungate Creek pilot areas, GPS telemetry data of mountain goats from January-April 2003 (n = 8 goats; n = 2651 locations) and November 2003-March 2004 (n = 5 goats; n = 1056) indicated that mountain goat movements were largely restricted to a single winter range area, although there was evidence of mountain goat movements between winter ranges in consecutive winters (Figure 5).

A complete aerial reconnaissance was not completed as part of the field monitoring. Although tracks were clearly visible during flights over and near the Foxy Canyon and Dungate Creek pilot areas, no tracks were detected between winter range areas because the terrain was entirely comprised of low elevation forest.
No telemetry data were available for the Howe Sound pilot area. Tracks within the winter range were clearly visible from the air, but flight times were inadequate to inventory the surrounding area for evidence of tracks between winter ranges areas.

3a. Ecological Baselines for Evidence of Movement Among Winter Ranges

Ecological baselines related to evidence of movement among winter ranges are difficult to establish because a failure to detect movements among winter ranges does not necessarily indicate the winter ranges are ineffective. Nor does it necessarily mean that the intervening forest matrix is unsuitable for movement of mountain goats. Mountain goat movements are highly variable and there is no reason to assume that every goat would necessarily use two or more ranges. If detecting the movements of only a few goats is expected, the resulting data would be a poor indicator of movement patterns of the local population.

4. Forage Availability

Evidence of feeding by mountain goats was found within only one plot at Dungate Creek bluffs where goats had been cratering for ground forage at an exposed site. In addition, “long-lining” tracks resulted in evidence of feeding on subalpine fir (Abies lasiocarpa) blowdown in a group selection site. Shrub cover was variable but evidence of feeding was not detected, nor was feeding on the sparse lichen litterfall evident.

I found evidence of browse throughout the area surveyed in the Howe Sound pilot area; however, use could not be identified to species because the area was also used extensively by wintering black-tailed deer (Odocoileus hemionus columbianus).

4a. Ecological Baselines for Forage Availability

Given the varied diets of mountain goats and the relative paucity of evidence of feeding expected in the field, ecological baselines related to forage availability are generally impractical.

Figure 5. Spanning tree diagrams from GPS telemetry data collected on collared mountain goats from January-April 2003 (n = 8 goats; n = 2651 locations) and November 2003-March 2004 (n = 5 goats; n = 1056). Different colours represent different goats. Spanning trees are restricted to a single winter season.
5. Snow Depth and Consolidation

Snow at Foxy Creek habitat plots was 23-62 cm (n = 7) deep and depths were correlated with percent crown closure (Figure 6). Sinking depths were 13-23 cm (n = 7) and did not change significantly with changes in crown closure (Figure 6). Dungate Creek winter range plots were all in low-canopy conditions because they were located in high-elevation ESSFmc forests. Snow there was 82-88 cm deep (n = 2) in forested sites and 37 cm deep at an exposed site located above mountain goat escape terrain.

![Figure 6. Relationship between canopy closure and mean snow depth and sinking depth in assessment plots at the Foxy Creek pilot area.](image)

The role of snow depth in restricting forage opportunities is less clear, primarily because evidence of feeding was relatively rare and mountain goats are known to have diets that vary with available forage (Laundré 1994). Feeding evidence at monitoring plots varied between cratering for ground forage and browsing blowdown.

In contrast, the low elevation portions of the winter range surveyed in the Howe Sound pilot area had very limited snow cover. This was due in part to the timing of the survey (23 March). Under canopy, snow cover was completely absent <450 m elevation and but was continuous >750 m (Figure 7). Without canopy closure there were intermittent snow patches 11-20 cm deep within a plot at 432 m elevation and >1 m deep within a plot at 774 m. Although there were no tracks in the deep snow at 774 m, there were tracks sinking 10 cm under canopy in snow depths of 30-60 cm with a crust layer at 30 cm.

5a. Ecological Baselines for Snow Depth and Consolidation

Deep snows impose higher energetic costs through both reduced mobility and reduced forage availability. Literature from similarly sized ungulates (e.g., mule deer) suggest that mobility becomes increasingly restricted as snow depths exceed 25 cm and can significantly restrict use if depths exceed 50 cm (Ungulate Winter Range Technical Advisory Team 2004 and references therein). These depths correlated well with observations at the Foxy Creek and Dungate winter range areas.
Based on these results, a proposed ecological baseline is to ensure that conditions on winter ranges result in snow depths of generally <40 cm and sinking depths of <25 cm.

Establishing ecological baselines for snow depths related to forage availability is more difficult because of the adaptability of mountain goat diets and the lack of information on energetic or fitness consequences of switching food sources as snow depths increase.

6. Evidence of Sustained Winter Use

Sign of mountain goat use was clearly evident in the Foxy Canyon pilot area. The most common sign was recent tracks, followed by pellets, evidence of urination, and feeding (Figure 8). In addition, sites of intense use near the canyon rim were discovered that could be used to establish pellet removal plots, in order to monitor use between years (Figure 9). Nearly all evidence of use was found under forest canopy. Evidence of use in managed stands (including a group selection site and clearcut blocks currently in structural stage 3) was rare and restricted to a few tracks and evidence of feeding.

At the Dungate Creek winter range, tracks in and among above rock outcrops were clearly visible at distances of >100 m (Figure 10); however, tracks were absent from deeper snow areas on the plateau above the escape terrain.

Identifying use by mountain goats in the winter range surveyed in Howe Sound was more difficult because the area was clearly being used by black-tailed deer, particularly at lower elevations. Pellets of black-tailed and mountain goats could be distinguished with some certainty and the presence of hair in some instances confirmed the identification. Use by mountain goats was not detected <600 m elevation. Tracks were also common on the Howe Sound winter range, but the snow as melting and the tracks could not be identified to species.

Figure 7. Continuous snow cover under dense forest canopy at 750 m in Howe Sound winter range. Snow under canopy was <30 cm while snow in the open was >1 m.

Figure 8. Evidence of use by mountain goats, including tracks, pellets and urine, found within forested portions of the Foxy Canyon pilot area.
6a. Ecological Baselines for Sustained Winter Use

The ecological baseline for sustained winter use should simply be continued evidence of use and, where permanent pellet removal sites can be established, continued relative use over time (no statistically significant change over >2 years).

Discussion

Pilot Project Areas

The project areas captured a great deal of the variation in both biology of mountain goats and management/policy related to developing mountain goat winter range plans. The Foxy Canyon pilot area is occupied by canyon-dwelling mountain goats of the interior ecotype, while mountain goats at the Dungate Creek area reside in more typical, high-elevation terrain. Howe Sound is home to coastal ecotype mountain goats that winter in steep, snow-shedding ranges at various elevations. Suitable habitat in Foxy Canyon and Dungate Creek was mapped by a model based on local inventory and studies. The Howe Sound ranges were developed and confirmed by aerial reconnaissance.

The timing of the fieldwork also resulted in the sampling of a range of climatic conditions, from mid-winter conditions at Foxy Canyon and Dungate Creek to early spring at Howe Sound. Although more low-elevation use by mountain goats might have been detected earlier in the season in Howe Sound, deeper snow would have made the area impossible to survey because of the steep terrain.

Monitoring Protocols

Although this report piloted the field component of the monitoring protocols, the office protocols are equally important and might constitute the majority of monitoring activities in some areas. Field monitoring is expensive and technically difficult or impossible in some areas. However, there is no substitute for ground-based work when assessing habitat characteristics and use by mountain goats under the forest canopy. The mix of office versus field monitoring is expected to vary between areas and perhaps between years as resources are available.

1. Proportion of Suitable/Capable Habitat Managed as Mountain Goat Winter Range

This step might or might not be possible for a given area, depending on how winter ranges are drafted in each district. In coastal areas where some winter ranges have been “grandparented” for many years, the original rationale for areas, with respect to either biology or policy might not be obvious. In areas where winter ranges have recently been mapped, or are in the process of being mapped, there is usually an independent biology-based map, usually generated by a habitat model, and then verified through further investigation. In these situations, the proportion of suitable or capable winter range habitat under management can be calculated.

2. Forest Cover Characteristics

Monitoring forest cover changes over time is a relatively simple office procedure. Forest cover on goat winter ranges is most threatened by blowdown along edges with recent cutblocks. Catastrophic events such as beetle kill or fire are also risks that vary depending on the areas of the province.

Forest cover is not a critical variable in itself for mountain goats, but it serves a number of critical purposes. First, dense canopy closure can moderate energetic costs by reducing snow depths on the ground. Second, older forests can also be an important source of lichens, which mountain goats eat when other more palatable food sources becomes unavailable. Finally, forested buffers around escape terrain can provide some protection against disturbance, to which...
mountain goats appear to be particularly sensitive (Wilson and Shackleton 2001).

In the case of Foxy Canyon (away from the Canyon rim) and Howe Sound, forest cover was critical for moderating snow depths and allowing mountain goats to move throughout the winter range. At Dungate Creek, mountain goats relied more on wind and snow-shedding on exposed rock outcrops to reduce snow depths in areas they used.

3. Evidence of Movement Among Winter Ranges

Monitoring movement among winter ranges is a significant challenge in determining the effectiveness of habitat managed for wintering mountain goats. Telemetry data are rare and most studies are conducted for only a few years; therefore, telemetry data can not be relied upon to monitoring movements over the long-term as the forest matrix changes. Observation of tracks on aerial survey flights provide anecdotal information at best, because tracks are visible only in unforested areas. Even where winter ranges are separated by expanses of unforested habitat, movements are still difficult to detect because mountain goats can remain on specific winter ranges for long periods and move to different areas only infrequently (e.g., Taylor et al. 2004).

In addition, ecological baselines are difficult to establish because movement patterns of mountain goats are highly variable and there is no a priori basis for assuming that movement between winter ranges is a key life requisite, particularly when the scale of winter range areas varies across the Province.

In this instance it might be better to infer movements between winter ranges from other indicators. For instance evidence of sustained use indicates that mountain goats are reaching the winter range area and that the condition of the

Figure 9. Intense use site near canyon rim at the Foxy Canyon pilot area. Areas such as these could be used to establish small pellet removal plots to monitor relative use between years.

Figure 10. Mountain goat tracks among and above rock outcrops at the Dungate winter range area.
intervening forest matrix is not serving as a barrier to movement. Where monitoring indicates that use by mountain goats is in decline, hypotheses regarding the reasons for the decline could be tested with monitoring data. For example, data could indicate whether the decline could be a function of changing ecological conditions in the winter range itself, in the surrounding forest matrix, other anthropogenic features (e.g., new roads or other development), or declines in local mountain goat populations.

4. Forage Availability

Because mountain goats have varied diets that depend largely on availability (Laundré 1994), monitoring forage availability might not be particularly useful. In addition, evidence of feeding was rarely encountered during pilot fieldwork in the pilot areas. Evidence was most common in the Howe Sound pilot area, but use could not be attributed definitively to mountain goats because the area was also used extensively by black-tailed deer.

Although energetic or fitness consequences are expected when mountain goats switch from feeding on higher-quality food items to lower quality items (e.g., forbs and conifers, respectively), there are no studies that have quantified these consequences in the field. Beyond qualitative assessments of forage availability (e.g., shrub cover and lichen litterfall), more formal monitoring of forage is probably impractical.

5. Snow Depth and Consolidation

Snow depth and consolidation are key variables on winter ranges because they can influence energy balance by restricting mobility and access to forage (although as noted above the consequences of restricting access to forage are difficult to quantify). Maintaining high canopy closure in order to reduce snow depths on the ground in areas surrounding escape terrain results in the principle timber supply impact to the forest industry. Characterizing and monitoring this relationship is therefore an importance focus of effectiveness monitoring. These data are also relatively easy to collect during ground-sampling and to analyze. Monitoring snow depths in a variety of forest types and structural conditions will provide valuable baseline information.

Ecological baselines related to snow depth and consolidation are relatively easy to establish based on the relationship between observed tracks and snow depths, and direct measurement of track depths. The preliminary baselines I have recommended, i.e., snow depths <40 cm and sinking depths <25 cm can be confirmed through additional field sampling.

6. Evidence of Sustained Winter Use

Evidence of use by mountain goats during consecutive winters over the long term is the most important indicator of the effectiveness of winter ranges. In areas of low or non-existent canopy closure this can be established relatively easily and quickly using reconnaissance-level aerial surveys to look for tracks and animals. However, use of heavily timbered areas cannot be determined from the air and, arguably, use in these areas is most important to establish because retaining these forested buffers creates the most significant timber supply impact.

Evidence of use was relatively easy to confirm on the ground under the forest canopy, although not all areas and conditions will be as favourable as the pilot areas investigated during this project. Nor will it be practical to investigate all winter ranges through field sampling because of safety concerns. The systematic bias created by sampling home ranges that are relatively accessible and safe to traverse should be considered in the interpretation of any results. In addition, areas where winter ranges of mountain goats overlap with those of other species can create challenges for definitively identifying use to species. Evidence of use can be classified to species only under ideal conditions.
Adaptive Management

Effectiveness monitoring is a key task in the adaptive management process and results form the basis for future adjustments to habitat management for mountain goats. Adaptive management relies on variation in management “treatments” to test different policies and practices (Walters 1986, Sit and Taylor 1998). As a result, the adaptive management process is most effective where monitoring is extensive and encompasses as broad a range of ecological conditions and management practices as possible. Extensive monitoring also tends to increase the overall robustness of management because it promotes an understanding of the full range of suitable ecological conditions and appropriate practices. As a result, management can move beyond attempting to achieve to a single optimum condition and can instead focus on managing the system within a range of acceptable outcomes using a more extensive policy and practices “toolbox” (Johnson 1999).

There are many factors (as well as interactions among factors) that determine the effectiveness of winter range areas managed for mountain goats. In addition, there are external factors that can influence the indicators used to measure effectiveness. For example, sustained use by mountain goats of an area is a function not only of habitat characteristics, but also of trends in local mountain goat populations, which are affected by climatic events (e.g., severe winters), disease, hunting regulations, etc. As a result, the effectiveness of winter ranges must be inferred from the weight of evidence provided by a number of indicators. In a complex system such as this, the evidence could be conflicting or contradictory and managers must carefully weigh the different lines of evidence and document the logic of his or her expert-based conclusions.

There will also be uncertainty in how to respond to unacceptable outcomes. Although extensive monitoring will increase our understanding of the ecological system and its response to different management practices, it is generally impractical to establish controlled and replicated “management experiments” to definitively test the efficacy of all policy and management options. Again, the evidence will need to be weighed and conclusion documented.

Although this situation does not represent the ideal adaptive management scenario, it will still provide a much better basis than exists now for decision-making, as well as a framework for continual improvement.

Conclusions and Management Recommendations

The results of this pilot monitoring project have suggested a number of revisions and modifications to the indicators recommended by Wilson (2005a; Table 3). The revised indicators and desired conditions should provide a practical basis for monitoring the effectiveness of winter ranges established for mountain goats.

Table 3. Recommended indicators and desired conditions for ungulate winter ranges established for mountain goats (Wilson 2005a) with conclusions and recommendations from the pilot study.

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>DESIRED CONDITION/RESULT</th>
<th>CONCLUSIONS &amp; RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of area in established Ungulate Winter Range relative to available suitable winter range habitat</td>
<td>All suitable and occupied winter ranges protected/all capable winter ranges protected (depending on management objective)</td>
<td>An independent and reliable assessment of all suitable and capable habitat will not be possible in all areas but should be conducted where data are available. Because occupation of winter ranges can vary among years and inventory might be inconsistent, all suitable habitat should be assessed.</td>
</tr>
<tr>
<td>INDICATOR</td>
<td>DESIRED CONDITION/RESULT</td>
<td>CONCLUSIONS &amp; RECOMMENDATIONS</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Forest cover characteristics</td>
<td>Contiguous old forest on ranges below tree line except for small openings associated with rock outcrops</td>
<td>Characterizing forest cover should focus on blow-down and forest health assessments, as well as canopy closure estimates at field plots.</td>
</tr>
<tr>
<td>Forage availability</td>
<td>Abundant and available preferred rooted forage and litterfall</td>
<td>Assessing forage availability is generally impractical for mountain goats.</td>
</tr>
<tr>
<td>Snow depth and consolidation</td>
<td>Shallow snows that do not affect the mobility of mountain goats or access to available, preferred forage</td>
<td>Snow data should be correlated with canopy closure and other biogeoclimatic characteristics to provide baseline information on habitat conditions that significantly reduce snow depths.</td>
</tr>
<tr>
<td>Evidence of sustained winter use by mountain goats</td>
<td>Observations of mountain goats in designated UWR by commercial backcountry recreation operators</td>
<td>These data will likely be limited because operators are requested to avoid winter ranges; however, data collected on reconnaissance and inventory surveys should be used to establish evidence of sustained use. Data might also be available in future from other resource users.</td>
</tr>
<tr>
<td>Evidence of sustained winter use by mountain goats</td>
<td>Evidence of browse, presence of pellet groups, tracks, direct observations</td>
<td>Field assessments of use are important in forested areas and should be conducted where practical.</td>
</tr>
<tr>
<td>Evidence of movement among winter range areas</td>
<td>Telemetry locations indicating movement among winter range areas through different habitat conditions</td>
<td>Although important anecdotal information, data are expected to be scarce and cannot be used to assess barriers to movement definitively.</td>
</tr>
</tbody>
</table>

Field methods as proposed were generally practical. The exception was the suggestion of a transect along a fixed bearing moving up or downslope. In many areas the ability to navigate steep or broken terrain will make travelling along a fixed bearing difficult or impossible. In other areas, a different sampling strategy might result in better ecological coverage or a better chance of detecting mountain goats (e.g., following a canyon rim).

Now that many of the indicator methods have been tested and refined, the next step is to develop an implementation plan that includes:

1. Roles and responsibilities for collecting, analyzing and warehousing data;
2. A mechanism for approving and documenting required changes to management when unacceptable outcomes are encountered; and,
3. Office and field manuals that concisely present for practitioners the monitoring protocols, data capture requirements and analysis methods.


RIC (Resources Inventory Committee). 2002. Aerial-based inventory methods for selected ungulates: bison, mountain goat, mountain sheep, moose, elk, deer and


Appendix I

Suggested field card for collecting data related to assessing the effectiveness of mountain goat winter ranges. Roman numerals refer to custom fields, numbers and letters to Resources Information Standards Committee fields (MELP and MOF 1998).

<table>
<thead>
<tr>
<th>SITE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Date:</td>
<td>(22) Succ Status:</td>
</tr>
<tr>
<td>(2) Plot Number:</td>
<td>(23) Struct Stage:</td>
</tr>
<tr>
<td>(3) Project ID:</td>
<td>(25) Site Disturb:</td>
</tr>
<tr>
<td>(5) Surveyors:</td>
<td>(26) Photo No:</td>
</tr>
<tr>
<td>(7) Forest Region:</td>
<td>(27) Elevation:</td>
</tr>
<tr>
<td>(8) Mapsheet:</td>
<td>(28) Slope:</td>
</tr>
<tr>
<td>(9) UTM zone:</td>
<td>(29) Aspect:</td>
</tr>
<tr>
<td>(10) X:</td>
<td>(30) Mesoslope:</td>
</tr>
<tr>
<td>(10) Y:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VEG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) Percent cover</td>
<td>(A) Trees:</td>
</tr>
<tr>
<td></td>
<td>(B) Shrub:</td>
</tr>
<tr>
<td></td>
<td>(C) Herb:</td>
</tr>
<tr>
<td></td>
<td>(D) Moss/Lichen:</td>
</tr>
<tr>
<td>(6/7) Dom spp and %</td>
<td>A1:</td>
</tr>
<tr>
<td></td>
<td>A2:</td>
</tr>
<tr>
<td></td>
<td>A3:</td>
</tr>
<tr>
<td></td>
<td>B1:</td>
</tr>
<tr>
<td></td>
<td>B2:</td>
</tr>
<tr>
<td>(LL) Lichen Load:</td>
<td>(v) Litterfall:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WHA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(13) Species</td>
<td>(16) Activity:</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(19) Comments - long-lining results:
# Appendix II

Suggested field card for collecting snow data at plots related to assessing the effectiveness of mountain goat winter ranges. Adapted from MSRM (2002).

## Snow Data Collection Card

<table>
<thead>
<tr>
<th></th>
<th>Snow depth (cm)</th>
<th>Crust depth (cm)</th>
<th>Sinking depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

---

**SNOW**

- Date:
- Plot Number:
- Project ID:
- Surveyors:
- Forest Region:
- Mapsheet:
- UTM zone:
- X:
- Y:
- Elevation:
- Temperature:
- Precipitation:
- Site description:

---

**EcoLogic Research**

*Monitoring the effectiveness of mountain goat habitat management*