

WILDLIFE HABITAT AREA EFFECTIVENESS EVALUATIONS  
Protocol for Monitoring the Effectiveness of  
Badger Wildlife Habitat Areas

Version 1.4

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## 1.0 Introduction

One goal of the British Columbia *Forest and Range Practices Act* (FRPA) is to conserve biological diversity, including plant communities and wildlife habitat, with reference to the impacts of forest and range activities. Under FRPA, the Ministry of Environment (MoE) is authorized to establish habitat management strategies for species designated within the Identified Wildlife Management Strategy (IWMS; Ministry of Water, Land and Air Protection 2004). Designated species can be managed through the establishment of Wildlife Habitat Areas (WHAs) that are established around key habitats considered to be most limiting to a particular Identified Wildlife taxon. General Wildlife Measures outlined in species accounts of the IWMS regulate activities within WHAs by identifying appropriate management practices and potentially prohibiting certain activities or limiting them during sensitive periods. Forest and range tenure holders are required to incorporate General Wildlife Measures within badger WHAs. They are also obliged to consider sustainable resource management and planning recommendations from the IWMS on all other Crown land and, in the case of tree farms or woodlot licenses, private land managed as part of those tenures.

Badgers (*Taxidea taxus*) are designated as Identified Wildlife under FRPA, and are potentially affected by forest and range activities. The subspecies of badger (*T. t. jeffersonii*) that occurs in the province is classed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and is red-listed in the province. Badgers are fossorial carnivores generally found in grassland and open forest habitats. Their main habitat requirements include suitable soil for burrowing and sufficient prey. A number of WHAs are proposed across the province for protection of important badger habitat. This document provides protocols for monitoring the effectiveness of badger WHAs to determine whether management objectives are being achieved.

The Forest and Range Resource Evaluation Program uses a 3-tiered approach to conducting effectiveness evaluations (Province of British Columbia 2004). The 3 levels (low, moderate, and high effort) are defined as follows:

*Routine:* relatively low-intensity evaluations calling for typically inexpensive and rapid data collection.

*Extensive:* moderate-intensity evaluations that collect categorical data by visual estimates of specified indicators at randomly selected sites.

*Intensive:* detailed evaluations that involve quantitative data collection and analysis with comparison to controls or benchmarks.

The level chosen depends in part on budget and indicators of WHA status. Based on methods outlined in this document, evaluations of at least the extensive level are required to determine WHA effectiveness. Intensive evaluations are likely to occur when there are indications that a WHA is not effective or when an opportunity to cooperate with other research or monitoring projects arises.

## 2.0 Monitoring Objectives

The goal of a badger Wildlife Habitat Area is to protect important habitat such as concentrations of burrow sites, especially maternal dens, concentrations of prey species and suitable soil

(Adams and Kinley 2004)<sup>1</sup>. To determine whether this objective is met, it is necessary to regularly evaluate a WHA's effectiveness, i.e. (a) whether it supports badgers and (b) the degree of risk that it will lose the ability to do so. Key monitoring questions (Hoodicoff 2006) to determine whether a WHA is providing effective habitat for badgers include:

1. Is the habitat (burrows, soil and prey) within the WHA suitable for badgers?
2. Are there activities within or adjacent to the WHA that may disturb badgers or their key habitats?
3. Are badgers using the WHA and how regularly?
4. Are badgers using the WHA to reproduce or rear kits?
5. Are travel corridors between and adjacent to WHAs accessible and safe for badgers?

Effectiveness evaluations can be used to provide a baseline of use and habitat conditions within WHAs and to identify possible changes to management standards such as General Wildlife Measures (Appendix 1). Effectiveness evaluations should also be considered within the context of regional populations (e.g. Cariboo, East Kootenay, Thompson-Okanagan). WHAs alone will not be sufficient to conserve badgers regionally but they will make a significant contribution, and the evaluation of WHAs will be useful in identifying the need for other conservation strategies extending beyond their boundaries. Thus, effectiveness monitoring is used in the context of adaptive management (Ascaphus Consulting 2006).

### 3.0 Effectiveness Indicators

Indicators used in evaluating WHA effectiveness are identified below. All those listed under the routine and extensive categories have been or are being tested at the time of writing within the East Kootenay, with the exception of the traffic volume indicator. These indicators cover both functionality and risk ratings (Section 4).

#### 3.1 Routine (Low-Effort) Evaluations

The indicators selected by Hoodicoff (2006) for routine evaluations included:

1. Area of suitable habitat alienated (GIS-based).
2. Change in percent canopy (GIS-based).
3. Road density by road type (GIS-based).
4. Number of road mortalities, based on existing reporting lines, contact with tenure holders, and the Ministry of Transportation's (MoT's) Wildlife Accident Reporting System (WARS) database (office-based).

We propose 2 additional indicators:

5. Traffic volume on adjacent roads, where data are available from MoT; to be combined with road density and road mortality evaluations (office-based).
6. Rapid on-site assessments to check for obvious issues that may not otherwise be detected through routine evaluations, such as recent developments on the WHA periphery or degradation of the WHA through off-road vehicle use (field-based).

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<sup>1</sup> The term "friable" used by Adams and Kinley (2004) in describing suitable soil has mainly agronomic connotations; suitable soil for badger burrows is likely more a function of depth, drainage, moisture wicking ability, particle size and other structural properties.

### 3.2 Extensive (Moderate-Effort) Evaluations

The indicators selected by Hoodicoff (2006) for extensive evaluation include:

1. Badger burrow density (field-based).
2. Range status (field-based).
3. Presence of a family group (office- or field-based). The extensive evaluation would be based on identification of a possible maternal den or sightings of a family group. More involved techniques are considered under intensive evaluations.

We propose adding 2 other field-based indicators:

4. In areas of the province where ground squirrels are a primary food source, such as the East Kootenay, determine density of recent ground squirrel burrows as a key (perhaps primary) indicator of habitat quality. Other food sources are not amenable to rapid, accurate assessments.
5. In cases where highways abut WHAs, use the badger burrow density data to assess whether badger activity in the WHA is disproportionately near the highway.

### 3.3 Intensive (High-Effort) Evaluations

The indicators selected by Hoodicoff (2006) for intensive evaluations all require evaluation by the use of remote cameras or hair snagging for DNA. They include:

1. Number of badgers using WHA (based on hair-snagging techniques).
2. Presence of a female or family group (based on hair-snagging or remote cameras rather than the opportunistic sightings considered under extensive evaluations).
3. Frequency of burrow use (based on remote cameras or hair-snagging).

Each method can be opportunistically supplemented by radiotelemetry-based projects that may involve badgers using WHAs.

## 4.0 Assessing WHA Effectiveness

WHA effectiveness is to be evaluated based on the monitoring objectives outlined in Section 2.0, the recommendations of Erickson et al. (2005) and Hoodicoff (2006), and further refinements proposed here. To clarify any potential inconsistency in language, we explicitly define “effectiveness” as a combination of the current functionality of a WHA and the degree of risk to its integrity. It is essential to consider both of these factors simultaneously. For example, a WHA may experience intensive use by badgers, yet be surrounded by private land that is being converted to housing developments. In such a case, the high effectiveness initially evident from current badger activity (functionality) is moderated by the increasing risk of isolation and harassment. The following sections provide definitions for each category of functionality and risk, and ratings for various combinations of those 2 factors. The indicators listed here are the same as those identified in Section 3, but identified as relating to either functionality or risk, rather than being organized by level of effort as in Section 3 (Table 1). Methods to monitor these indicators are provided in Section 5.

Table 1. Classification of indicators by level of effort required to monitor them, and whether they indicate functionality or risk.

Indicator	Level of Effort	Indicator Type
Area of suitable habitat alienated	Low (routine)	Risk
Change in percent canopy	Low (routine)	Risk
Road density by road type	Low (routine)	Risk
Number of road mortalities	Low (routine)	Risk
Traffic volume on adjacent roads	Low (routine)	Risk
Rapid on-site assessment	Low (routine)	Risk
Badger burrow density (and trends over time)	Moderate (extensive)	Functionality
Range status	Moderate (extensive)	Risk
Presence of a family group	Moderate (extensive)	Functionality
ground squirrel burrow density <sup>1</sup>	Moderate (extensive)	Functionality
badger activity disproportionately near highway	Moderate (extensive)	Risk
Number of badgers using WHA	High (intensive)	Functionality
Presence of a female or family group <sup>2</sup>	High (intensive)	Functionality
Frequency of burrow use	High (intensive)	Functionality

<sup>1</sup> where ground squirrels are a major food source

<sup>2</sup> distinct from moderate-effort (extensive) monitoring for family groups through visual sightings

## 4.1 Functionality

The ideal indicator of functionality would be the number of badgers or amount of badger activity that a WHA sustains. Because this is very difficult to determine, surrogates must be used. Two of these are the density of recently-occupied badger burrows<sup>2</sup> (and trends over several years in this density), and whether females or family groups are present. In theory, habitat quality would be another useful surrogate. However, evaluation of habitat from biophysical characteristics can be done at only a very coarse level, and our ability to correlate gradual habitat changes with badger density changes is almost non-existent. Habitat quality could also be predicted from prey-abundance estimates and trends but in some regions badger diets are not dominated by any single prey item, virtually all prey species vary annually or seasonally in abundance, and many species are difficult to survey (Hoodicoff 2006). One exception is that Columbian ground squirrels are by far the dominant prey item in the some areas, such as the East Kootenay, and their numbers can be readily indexed by searching for recently occupied burrows. Thus, the 3 indicators of WHA function are:

- the density of recent badger burrows, and trends over time in this density;
- whether female badgers or family groups have been observed; and
- where appropriate, the density of recent ground squirrel burrows.

There area also high-effort evaluations that are equivalent to these measures. If research indicates that badger diets for a given area (even at as fine a scale as a single WHA) are strongly dominated by a particular prey species, and if means of reliably indexing that prey species population can be developed, then additional prey-based local measures of WHA function would be feasible. Based on a modification of the categories proposed by Hoodicoff (2006), 3 WHA functionality categories are proposed (Table 2, Figure 1).

<sup>2</sup> The ability to determine whether burrows have been active during the year of the survey is key to this indicator. While most burrows can be classified as having been occupied during the current year versus only during previous years based on the presence of freshly disturbed soil, tracks or trampling, and degree of plant growth, variation by region, soil type or habitat use may result in this judgment call being considerably more difficult in some situations. See Section 4.4 for consequences of this situation.

Table 2. Badger WHA functionality categories based on indicators and modifiers to them. Recent ground squirrel burrow density is to be considered only where ground squirrels are the predominant prey item. If both modifiers are observed (negative badger burrow trend and high ground squirrel burrow density) they are considered to negate each other and functionality rating is assigned based on the main indicator alone.

Status of Main Indicator	Functionality Rating		
	<u>Based on Main Indicator Only</u>	<u>Based on Main Indicator Plus Modifier</u>	
		<i>If Trend in Recent Badger Burrows is Negative<sup>1</sup></i>	<i>If Density of Recent Ground Squirrel Burrows is High<sup>2</sup></i>
No family group or female present in past 6 years & density of recent badger burrows <sup>3</sup> is:			
• Nil	Not Functional	Not Functional	Moderately Functional
• Low	Moderately Functional	Not Functional	Highly Functional
• High	Highly Functional	Moderately Functional	Highly Functional
Family group or female present in past 6 years <sup>4</sup>	Highly Functional	Moderately Functional	Highly Functional

<sup>1</sup> Recent badger burrow density decline of at least 50% over 2 years. This equals a 30% annual decline. The requirement for a large magnitude of decline relates to the expected variability in badger activity patterns within WHAs and over broader spatial scales.

<sup>2</sup> Recent ground squirrel burrows are those that appear to have been occupied during the year of the biennial survey. Number of ground squirrel burrows required to qualify as “high density” is to be determined regionally based on observations from initial (baseline) WHA evaluations.

<sup>3</sup> Density of badger burrows (number/ha) that appear to have been occupied during the year of a biennial survey is to be extrapolated from transects. Densities corresponding to “high” are to be determined regionally based on observations from initial WHA evaluations, and will need to be adjusted to account for the time of year in which fieldwork occurs (i.e. more burrows of the current year would be expected in October than May; see Appendix 2). Alternately or additionally, the degree of use may be evaluated directly through camera or hair-snagging methods if intensive evaluations are undertaken.

<sup>4</sup> Presence of family groups known through sightings by the public, opportunistic observations by field crews (animals or apparent maternal dens), or intensive evaluation methods. Presence of a female known through intensive evaluation methods only, such as telemetry. The 6-year criterion accounts for 3 cycles of fieldwork occurring at 2-year intervals.

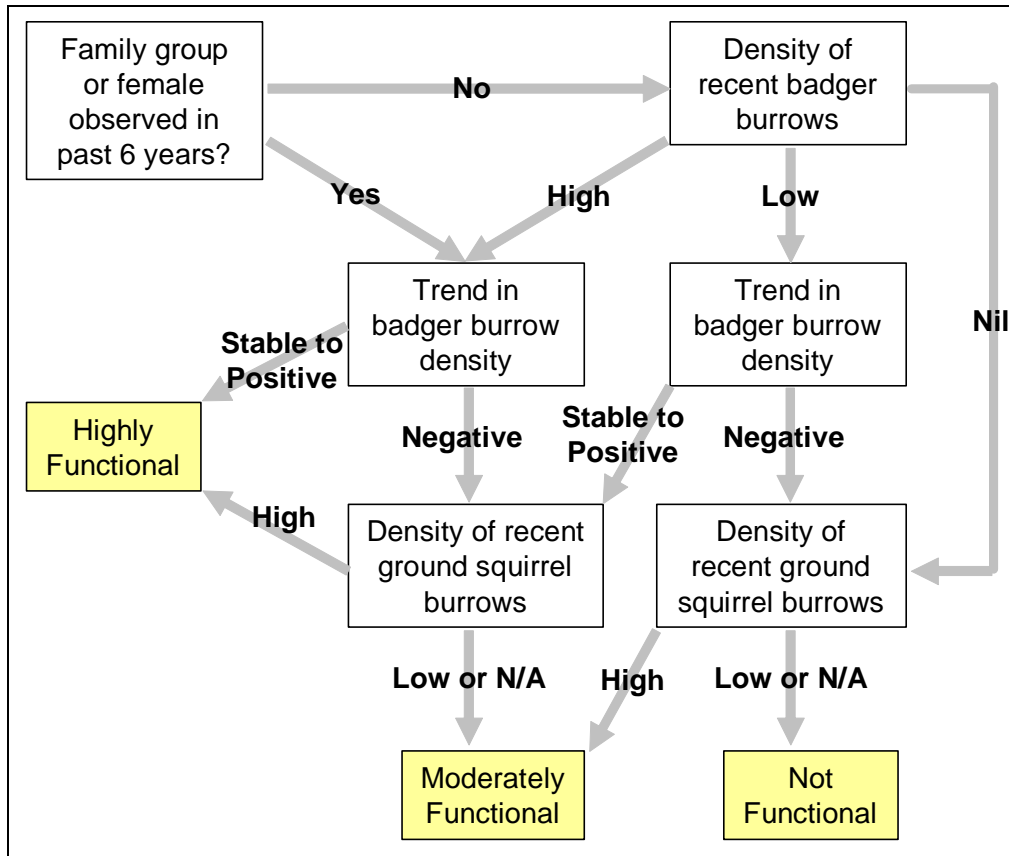


Figure 1. Assessment process for assigning badger WHA functionality ratings. Densities of recent (occupied during year of survey) badger or ground squirrel burrows considered to be “high” are to be determined regionally based on the results of baseline WHA assessments. Ground squirrel densities are to be considered only in regions where ground squirrels are the predominant prey. The density of recent badger burrows must decline by at least 30% annually (50% biennially) to be considered “negative”.

## 4.2 Risk

The risk that badgers will not continue using the WHA is to be evaluated by considering the following indicators. Other indicators of risk may become evident during evaluations. Methods of assessing these indicators are described in Section 5.

- Degree of land alienation, including adjacent rural, suburban, urban, recreational or industrial developments with the potential to cause barriers to movement, harassment and nuisance animal complaints.
- Trends in canopy closure within and near the WHA.
- Roadkill risk, as a function of:
  - road density within or near the WHA.
  - traffic volume on roads in or near the WHA.
  - adjacency of badger activity to a highway.
  - number of roadkills in or near the WHA.
- Rapid on-site assessment.
- Range status in WHA.

Based on the above factors, the degree of risk is to be subjectively assigned to 1 of 3 categories, listed in decreasing order of severity:

1. *Immediate Risk* – Risk factors are identified that are now impeding the ability of badgers to use the WHA, or are likely to do so within the next 5 years.
2. *Long-term Risk* – Risk factors are identified that will probably not significantly impede the ability of badgers to use the WHA within the next 5 years but are likely to do so within 10 years if left unchecked.
3. *Low to No Risk* – No or minimal risk factors are identified that will impede badgers' ability to use the site in the foreseeable future.

Conditions associated with increased risk are identified under the Criteria for Action sections of the Effectiveness Monitoring descriptions in Section 5. Those sections do not specify whether risk is low, long-term or immediate because each risk indicator can occur at a variety of magnitudes. Rather, WHA-evaluation personnel are to use monitoring results to subjectively assess whether enough risk factors of sufficient magnitude exist to warrant a long-term or immediate risk designation.

### 4.3 Effectiveness Categories and Management Thresholds

Combining the functionality and risk ratings, evaluations will place a WHA in 1 of 5 effectiveness categories (Table 3). The complete process of evaluating functionality and risk to rate effectiveness is shown in Figure 2.

Table 3. Badger WHA effectiveness categories as defined by functionality and risk ratings. Higher numbers correspond to greater effectiveness.

Functionality Rating	Risk Rating		
	Low to No	Long-term	Immediate
Highly Functional	5	4	3
Moderately Functional	4	3	2
Not Functional	2	1	1

Targets for effectiveness should be established for each WHA or for groups of WHAs. However, the criteria above suggest that an effectiveness rating of at least category 4 should normally be targeted. If so, ratings of 4 or 5 would not require a change in management regime or new actions aside from continued monitoring. An effectiveness rating of 1, 2 or 3 would indicate a need for management changes, such as those outlined within Section 5. In particular, effectiveness ratings of 1 or 2 would indicate an immediate need for action to prevent or reverse loss of a WHA's viability. It should also be noted that extensive evaluation methods described in Section 5 make it possible to confirm badger activity, but not to confirm any apparent lack of activity. Therefore, if extensive evaluations do not indicate recent badger activity, resulting in apparent low functionality and effectiveness ratings, intensive evaluations would be required before definitively assigning a low effectiveness rating.

In addition to WHA management regimes, regional badger population densities or fluctuations in prey abundance are likely to be driven by much broader land-management activities or ecological conditions and will almost certainly have profound effects within the WHAs. In such cases, many or all WHAs within a region are likely to receive poor effectiveness ratings simultaneously. Whether at the level of individual WHAs, groups of WHAs within a region, or WHAs in general across the province, effectiveness evaluations indicating unsatisfactory

conservation results require further inquiry and implementation of restoration or conservation initiatives that are outlined in the *jeffersonii* Badger Recovery Strategy (*jeffersonii* Badger Recovery Team 2005) or established regionally (e.g. Regional Implementation Groups).

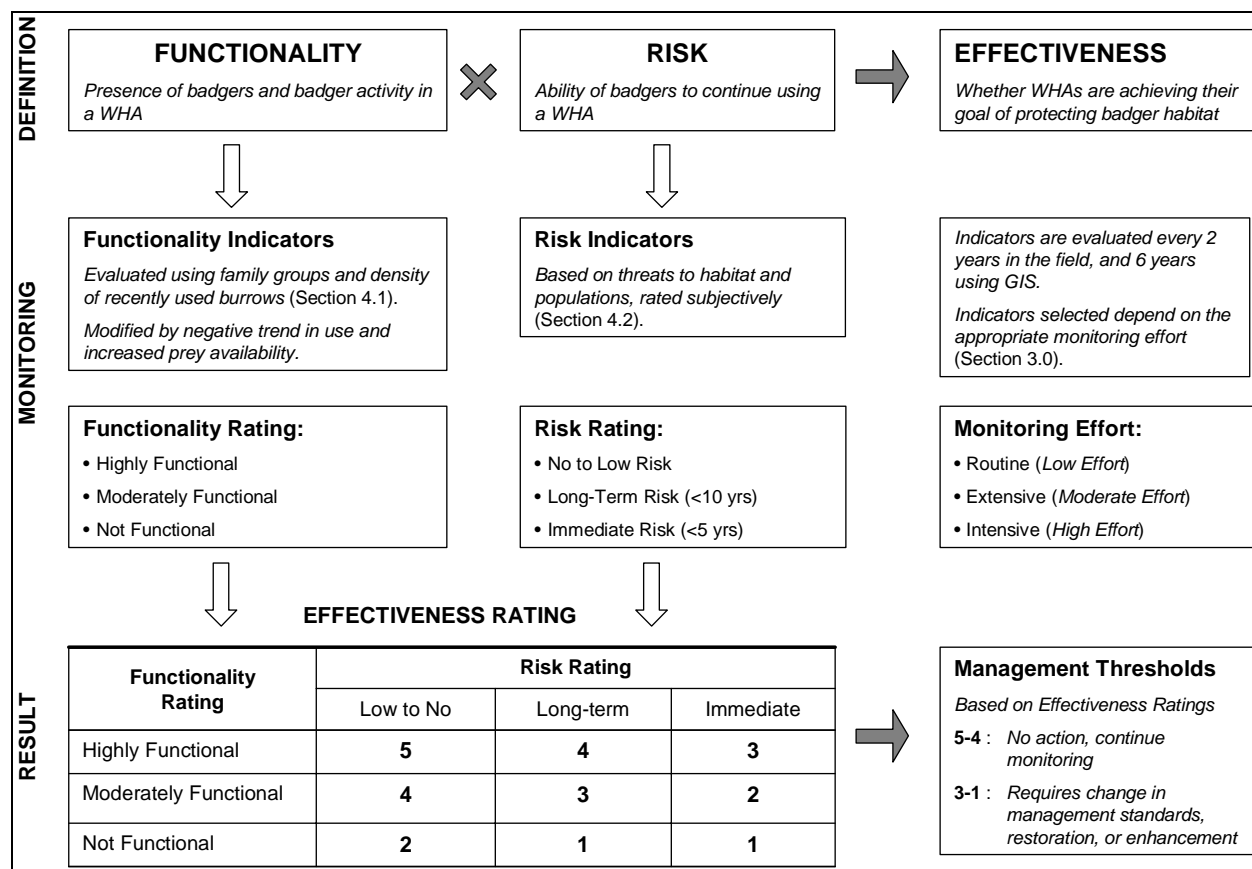


Figure 2. Badger WHA effectiveness evaluation summary.

## 5.0 Monitoring Methods

### 5.1 Level 1: Effectiveness Indicators Requiring Low Effort (Routine)

#### 5.1.1 Area of Permanent Habitat Loss

##### *Purpose*

To determine the amount of suitable habitat that is permanently alienated (e.g. lost to urban or industrial development or converted for intensive agriculture<sup>3</sup>) within the WHA and at local and landscape scales.

<sup>3</sup> The practice of livestock grazing on native grasslands is not considered habitat loss for badgers. Some agricultural land (primarily pasture) provides badger habitat, but for the purpose of this assessment it is assumed that conversion of native grasslands to lands classified as agricultural decreases badger habitat value. It is also assumed that conversion of either native grasslands or agricultural lands to urban/industrial or reservoir development represents a loss of badger habitat.

### *Operational Requirements*

- GIS coverages of WHA boundaries available through the MoE regional offices.
- Base mapping (e.g. roads, vegetation, cover types, etc.) for geographical reference (Appendix 3).
- GIS coverages compiled at 1:20,000 scale by the Grassland Conservation Council (GCC 2004; Appendix 3), including grassland/open forest (“open grassland – open range & open dry forest @ 0-10% crown closure”), agricultural (“clearing and cultivated – general agricultural lands”), and urban and industrial, including rights-of-way of major roads (“urban and industrial”). See the BC Grasslands portion of the Community Mapping Network for map layers and a link to metadata ([http://www.shim.bc.ca/atlasses/grassland/grassland\\_public.htm](http://www.shim.bc.ca/atlasses/grassland/grassland_public.htm)). In some areas, reservoirs (e.g. hydroelectric, recreational, domestic water, irrigation) have replaced historic grasslands, but GCC mapping does not indicate whether waterbodies are natural or man-made so habitat loss to reservoirs cannot be readily determined. If future mapping differentiates man-made reservoirs from natural waterbodies, include reservoirs as a category of alienated habitat.
- 1:20,000 mapping of the historic extent of grassland and open forest from GCC ([gcc@bcgrasslands.org](mailto:gcc@bcgrasslands.org)).

### *Office Procedures*

1. Within each WHA, identify areas classified as grassland/open forest, each of the 2 alienated land classes (urban and agricultural), and historic grassland/open forest.
2. Do the same within a 1-km and 3-km radius of the centroid of each WHA (“local” and “landscape” scales respectively). Use appropriate GIS software to determine the WHA’s centroid, then permanently record it so that future analyses are based on the same point.
3. Within the historic layer, query database to determine the amount of grassland/open forest that has been converted to agricultural and urban/industrial. Polygons labeled as rivers, lake or swamps should be removed from the analysis so that percentage change is based on land only.
4. As GCC mapping is updated, overlay updated mapping with the first-generation mapping to determine the amount of native grassland converted to agricultural, urban/industrial and water, and the amount of agricultural land converted to urban/industrial and water. If GCC mapping is not updated but forest cover or Vegetation Resource Inventory (VRI; Appendix 3) mapping is, recreate and update GCC categories using the conversion criteria outlined in the metadata associated with the BC Grasslands section of the Community Mapping Network.
5. Track and compare trends over spatial scales (within WHA versus local scale versus landscape scale) and over time (historic versus first-generation mapping versus updated mapping). Incorporate any information collected during site overviews (Section 5.1.6).

### *Sampling Frequency*

The area of suitable habitat lost from grassland and open forest at the landscape scale will help illustrate a relative value of habitat within a WHA in the context of a changing landscape. This indicator is considered a high priority. It is recommended that all GIS-based assessments be completed every 6 years to maximize the likelihood of up-to-date information layers being available. The 6-year period coincides with 3 cycles of biennial fieldwork (Section 5.2) and the recommended 6-year reporting period (Section 6). If updated GIS layers (either GCC mapping directly or forest cover/VRI mapping converted to GCC equivalents) are not available every 6 years, rough estimates of habitat loss can be obtained by conducting site overviews (Section 5.1.6).

### *Criteria for Action*

This indicator will show the trend in grassland habitat loss over time. Details and spatial patterns of habitat loss are important in assessing this, so firm criteria requiring action are difficult to identify. Subjective assessments of the results from the above analysis may identify the need and urgency to establish additional WHAs within a region, or to implement conservation actions that are identified within the *jeffersonii* Badger Recovery Strategy, such as private land stewardship and covenants.

## 5.1.2 Change in Percent Canopy Closure

### *Purpose*

To determine the temporary loss of grassland and open forest habitat as a result of forest in-growth within the WHA and at local and landscape scales. Information from GIS sources can be supplemented by field-based data regarding percent cover of the vegetative layers and range photo plots to assess in-growth rates.

### *Operational Requirements*

- GIS coverages of WHA boundaries available through the MoE regional offices.
- Access to crown closure information from VRI, forest cover, or other available sources (Appendix 3).

### *Office Procedures*

1. Identify crown closure classes (10% increments) for forest cover or VRI polygons within each WHA and total the area of each class<sup>4</sup>. Consider higher crown closure to be less valuable habitat. Use by badgers of stands with moderate canopy closures varies geographically, so calibrate the results using regionally appropriate habitat analyses (Weir et al. 2003, Hoodicoff and Packham 2006, Newhouse and Kinley 2006).
2. Do the same within a 1-km and 3-km radius of the centroid of each WHA (“local” and “landscape” scales respectively).
3. Track and compare trends over spatial scales (within WHA versus local scale versus landscape scale) and over time (comparing updated mapping at each 6-year reporting interval). Incorporate any information collected during site overviews (Section 5.1.6).

### *Sampling Frequency*

The conversion of grassland and open forest to forests with higher canopy closure translates to a loss of quality habitat for badgers, so this indicator is given a high priority. It is recommended that all GIS-based assessments be completed every 6 years to maximize the likelihood of up-to-date information layers being available. If updated forest cover or VRI Site mapping is not available every 6 years, rough estimates of habitat change can be obtained by conducting site overviews (Section 5.1.6).

### *Criteria for Action*

Coupled with field data collected on changes in percent cover of forest layers and grassland health, this indicator will show the trend in forest encroachment and in-growth over time. If significant changes are observed, ecosystem restoration within and outside the WHA may be required to mitigate these losses.

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<sup>4</sup> To obtain crown closure, join VRI polygons to the VRI “VEG\_POLYLAYER\_L1\_VW” data table.

### 5.1.3 Road Density by Road Type

#### *Purpose*

To determine the road density by road type as an indicator of mortality risk to badgers. By calculating the length of each type of road (paved, gravel, unimproved trail) in and adjacent to WHAs, an index of mortality risk can be determined. Primary paved roads represent the highest threats due to high traffic volumes and speed, while gravel roads pose less of a threat assuming lower traffic volumes and slower speeds. This index can be further refined if traffic volume data are available (see Section 5.1.4 below).

#### *Operational Requirements*

- Access to GIS coverages of WHA boundaries available through the MoE regional offices.
- Access to detailed road coverage data, which may be obtained from Terrain Resource Information Management (TRIM), Land Resource Data Warehouse (LRDW) or other available sources (Appendix 3).

#### *Office Procedures*

1. Identify length of each road type (paved, gravel, trail) within the WHA and calculate density as km of road per km<sup>2</sup>. Consider bridges to be roads, of the same type as the roads on which they are located. Omit railways, airports and overgrown roads from the database if those features are included in it.
2. Repeat within a 1-km and 3-km radius of the centroid of each WHA (“local” and “landscape” scales respectively). The effect of road density on badgers is likely to be minimal if badgers do not use the area in which the roads occur. Areas within natural disturbance type 3 (NDT3; Ministry of Forests and BC Environment 1995) are ecosystems with frequent stand-initiating events so typically provide badger habitat only when disturbed, those in NDT4 (ecosystems with frequent stand-maintaining fires) are more generally likely to provide badger habitat, and those in NDT5 (alpine tundra and subalpine parkland) provide very limited habitat. Therefore, where appropriate, truncate the assessment circles with reference to NDT as follows:
  - a. If the assessment circle of a WHA in the NDT4 also includes NDT3 or NDT5 areas, calculate road density only within that portion of the circle falling in the NDT4 to avoid considering effect of roads in areas potentially unused by badgers.
  - b. Where WHAs fall within the NDT3 it can be assumed that the NDT3 does in fact support badger habitat in the vicinity (as does the NDT4 generally). Therefore, include portions of the assessment circle falling within the NDT4 and NDT3, excluding only those portions in the NDT5.
  - c. If NDT mapping is not available, biogeoclimatic subzones or variants can be converted to NDT classes using tables in the Biodiversity Guidebook (Province of British Columbia 1995).
3. Track and compare trends in road density over spatial scales (within WHA versus local scale versus landscape scale) and over time (comparing updated mapping at each 6-year reporting interval). Incorporate any information collected during site overviews (Section 5.1.6).

#### *Sampling Frequency*

Road mortality is a significant factor in badger population status, so this indicator is given a high priority. It is recommended that all GIS-based assessments be completed every 6 years to maximize the likelihood of up-to-date information layers being available. If updated road mapping is not available every 6 years, estimates of changes in road density within and immediately adjacent to the WHA can be obtained through site overviews (Section 5.1.6).

### *Criteria for Action*

Where road densities within a WHA are greater than those at the local or landscape scale, or when densities at the local scale are greater than those at the landscape scale, the WHA will be considered at risk. However, this does not imply that the site is not functioning. For example, Newhouse and Kinley (2006) found that most telemetry and sightings records in the East Kootenay were from areas with road densities of  $>2.48 \text{ km/km}^2$ . Relative risk should be determined in the context of other roadkill-risk indicators, including traffic volume, number of road mortalities, and adjacency of burrows to highways. Mitigating actions, such as those recommended by the *jeffersonii* Badger Recovery Team (2005) including road signage, slower speeds and dry culvert crossings, should be implemented (Hoodicoff 2006). In order to achieve the greatest chance of success, efforts should be made to determine MoT plans for road upgrades so that culverts can be installed in conjunction with other works. In addition, existing culverts within 3 km should be checked to see if they are passable by badgers, and if not, if there are simple modifications that could be made to make them permeable.

## 5.1.4 Traffic Volume

### *Purpose*

To determine changes in traffic volume on highways adjacent to a WHA in order to assess mortality risk.

### *Operational Requirements*

Access to BC MoT traffic volume data. These data are likely to be spotty in its availability (check <http://www.th.gov.bc.ca/trafficData/index.asp>).

### *Office Procedures*

Review data and record traffic volume of highways adjacent to the WHA. Ensure that the exact segment and dates over which the data were collected is recorded for future comparison.

### *Sampling Frequency*

Road mortality is a significant factor in badger population growth. It is recommended that this assessment be completed every 6 years to maximize the likelihood of up-to-date information being available.

### *Criteria for Action*

Subject to future analyses indicating relationships between traffic volume and roadkill risk, we propose that mean volumes  $>1000$  vehicles/day during the spring, summer and fall be considered to put badgers in adjacent WHAs at risk. Relative risk should be determined in the context of other roadkill-risk indicators, including road density, number of road mortalities, and adjacency of burrows to highways. See Section 5.1.3 for potential actions.

## 5.1.5 Number of Road Mortalities

### *Purpose*

To determine the number of badger road mortalities near a WHA. This number will be an underestimate of the actual number of roadkills, as not all will be detected.

### *Operational Requirements*

- Access to regional badger sighting reporting lines (information and contacts are available on the *jeffersonii* Badger Recovery website at [www.badgers.bc.ca](http://www.badgers.bc.ca)).
- List of range and forestry tenure holders within WHA.
- List of potential ministry contacts (Ministry of Forests and Range [MoFR], MoE) who may be aware of badger roadkills in the area.
- Access to BC MoT Wildlife Accident Reporting System data (WARS). Reports are generally available on-line at [www.gov.bc.ca/tran/](http://www.gov.bc.ca/tran/) but the reports do not provide kill locations. For the actual data, contact Mr. Leonard Sielecki, BC MoT, Victoria ([leonard.sielecki@gov.bc.ca](mailto:leonard.sielecki@gov.bc.ca)). It should be noted that badgers are rarely recorded through this system and locations are not normally as precise as the badger sightings hotlines. Additionally, a data-sharing agreement must be signed with MoT in order to receive the locations. However, the database may contain some useful information and this may improve over time if highways contractors are issued GPS units for recording wildlife kill locations.

### *Office Procedures*

1. Review regional sightings databases to determine the number of roadkills recorded within 3 km of the centroid of the WHA in the previous 6 years. Contact range and tenure holders, and ministry contacts to determine if they have observed any un-recorded kills. At the same time, ask if they have observed any family groups within the WHA. Once these stakeholders are identified, it would be efficient to ask that they submit any sightings to the reporting lines.
2. Check for any possible roadkill records through WARS. Ensure that these are cross-referenced with the badger sightings databases to avoid duplication.
3. Enter all badger roadkill locations within 3 km of a WHA in the database. A separate worksheet is available for roadkill locations.

### *Sampling Frequency*

This indicator is considered a high priority (Hoodicoff 2006) and we propose it be conducted every 2 years.

### *Criteria for Action*

WHAs with any badger road mortality occurring within 3 km over the previous 6 years will be considered at risk (Hoodicoff 2006). Relative risk should be determined in the context of other roadkill-risk indicators, including road density, traffic volume, and adjacency of burrows to highways. See Section 5.1.3 for potential actions

## 5.1.6 Rapid On-site Assessment

### *Purpose*

To use a rapid site visit to identify obvious risk factors influencing the WHA that may not be evident from GIS-based or other office-based methods, or which may not be evident until updated resources (such as air photos) are available.

### *Operational Requirements*

- Paper map of WHA printed at sufficient resolution to identify site location and boundaries and with UTM grid (supplement with other maps showing roads, forest cover, topography, etc. if required).
- Waterproof notebook

- Hand-held GPS
- Pens, pencils

#### *Office Procedures*

Ensure familiarity with WHA boundaries, access to it, and roads within and near it.

#### *Field Procedures*

Drive through designated roads in the WHA and on public land immediately adjacent to it. Walk through portions not accessible by road. Prioritize inspection of the WHA boundary. Average roughly 1 to 10 min/ha of WHA area, depending on its size (less time/ha for larger sites). Determine whether there exist any obvious risk factors with the potential to significantly impact the ability of badgers to use the site, either positively or negatively. Primary issues include, but are not limited to, recent land development adjacent to the WHA, habitat losses to off-road vehicle use, creation of new roads, recent forest harvesting or ecosystem restoration, weed infestations sufficient to influence prey habitat, and non-permitted activities. Record observations, store them electronically, and provide them to regional and provincial personnel in agencies with responsibility for the WHA.

#### *Sampling Frequency*

This indicator is considered a high priority and we propose it be conducted every 2 years. This evaluation or an approximation of it will be conducted by default whenever burrow surveys are undertaken, which is also intended to be on a biennial cycle. However, in the event that burrows are not surveyed every 2 years, the site overview provides a cost-effective means of regularly ensuring that significant impacts to WHA status are not overlooked.

#### *Criteria for Action*

The need for action will depend on whether any urgent priorities not identified through other means are identified during the field inspection.

## 5.2 Level 2: Effectiveness Indicators Requiring Moderate Effort (Extensive)

### 5.2.1 Badger and Ground Squirrel Burrow Densities

#### *Purpose*

To record the presence and condition of badger burrows and, if appropriate, Columbian ground squirrel burrows and compare trends over time. Columbian ground squirrel burrows are a critical badger food source in some parts of British Columbia. In areas where alternate food sources are equally or more important, do not complete ground squirrel burrow surveys.

#### *Operational Requirements*

- Ability to identify and classify (current year versus older) badger and ground squirrel burrows
- GIS map of WHA boundary
- Burrow data form and database template
- Waterproof notebook
- Hand-held GPS
- Pens, pencils
- Compass
- Measuring tape or rope (2 m and 5 m)

- High-visibility vest
- 2 field technicians

#### *Office Procedures*

1. Using GIS, overlay a 100 m X 100 m grid on the WHA (Figure 3). Since badger and ground squirrel activity is frequently associated with edges, include all 100-m units that are even partially within the WHA. Lay out transects so that the maximum edge per transect is surveyed (either N-S or W-E). For example, if the WHA is longer N-S, transects would be run W-E.
2. Label each grid line, from north to south or west to east, with a unique number.
3. In the database, generate transect segment numbers in 50 m intervals (ie. 1-1, 1-2 would be the first 100 m of the northwestern transect). The number of burrows in shorter segments will be accounted for proportionately during data analysis.
4. Print blank data forms (including transect segment numbers and corresponding UTM's) and a map with grid lines on waterproof paper.
5. Ensure that you have the most recent blank database for entering standardized data. A blank database has been created that is consistent with the Wildlife Species Inventory Program (<http://srmwww.gov.bc.ca/wildlife/wsi/index.htm>).

#### *Field Procedures*

1. Conduct work between April and September.
2. Use a hand-held GPS to determine the start point of each transect segment. Use a compass to walk straight W-E or N-S depending on the transect orientation. Use the GPS to determine 50 m in length. Adjust the samplers' position at each 50-m interval using GPS.
3. To conduct den searches (Ministry of Environment, Lands and Parks 1999), walk grid lines and count and GPS all badger burrows within 5 m perpendicular to either side of the transect. Record whether the burrow is recent (i.e. used within the current year), or old (i.e. not used within the current year). Make a special note of possible maternal dens, which often have large piles of soil, show signs of longer-term use (i.e. multiple tracks, trampling), and often multiple entrances.
4. Along the same transect, count, but do not GPS, all ground squirrel burrows within 2 m perpendicular to either side of the transect. If 1 or more burrows within the segment are recent, code the entire segment as "recent" for ground squirrels. This fixed-width transect is consistent with provincial inventory standards (Ministry of Environment, Lands and Parks 1998).
5. Convert number of burrows per 50-m segment of transect to burrow density per hectare by multiplying the number by 20 for badgers ( $50 \text{ m} \times 10 \text{ m} = 500 \text{ m}^2 = 500/10,000 \text{ ha} = 0.05 \text{ ha}$ ) and 50 for ground squirrels ( $50 \text{ m} \times 4 \text{ m} = 200 \text{ m}^2 = 200/10,000 \text{ ha} = 0.02 \text{ ha}$ ). Also, calculate an overall density for the WHA using the same methods.

#### *Sampling Frequency*

This indicator is considered a high priority (Hoodicoff 2006) and we propose it be conducted every 2 years. Hoodicoff (2006) proposed an annual survey because it allows for a relatively simple surrogate for badger inventory and can help to determine the general frequency of use of burrows, but given the large size of many of the proposed WHAs, an annual survey may be cost-prohibitive. Sightability of the burrows will vary depending upon the time of year, but within 2 m (ground squirrels) and 5 m (badgers) all burrows should be seen regardless of the vegetation height. We have made the timing of surveys flexible to accommodate field schedules and multiple site samplings.

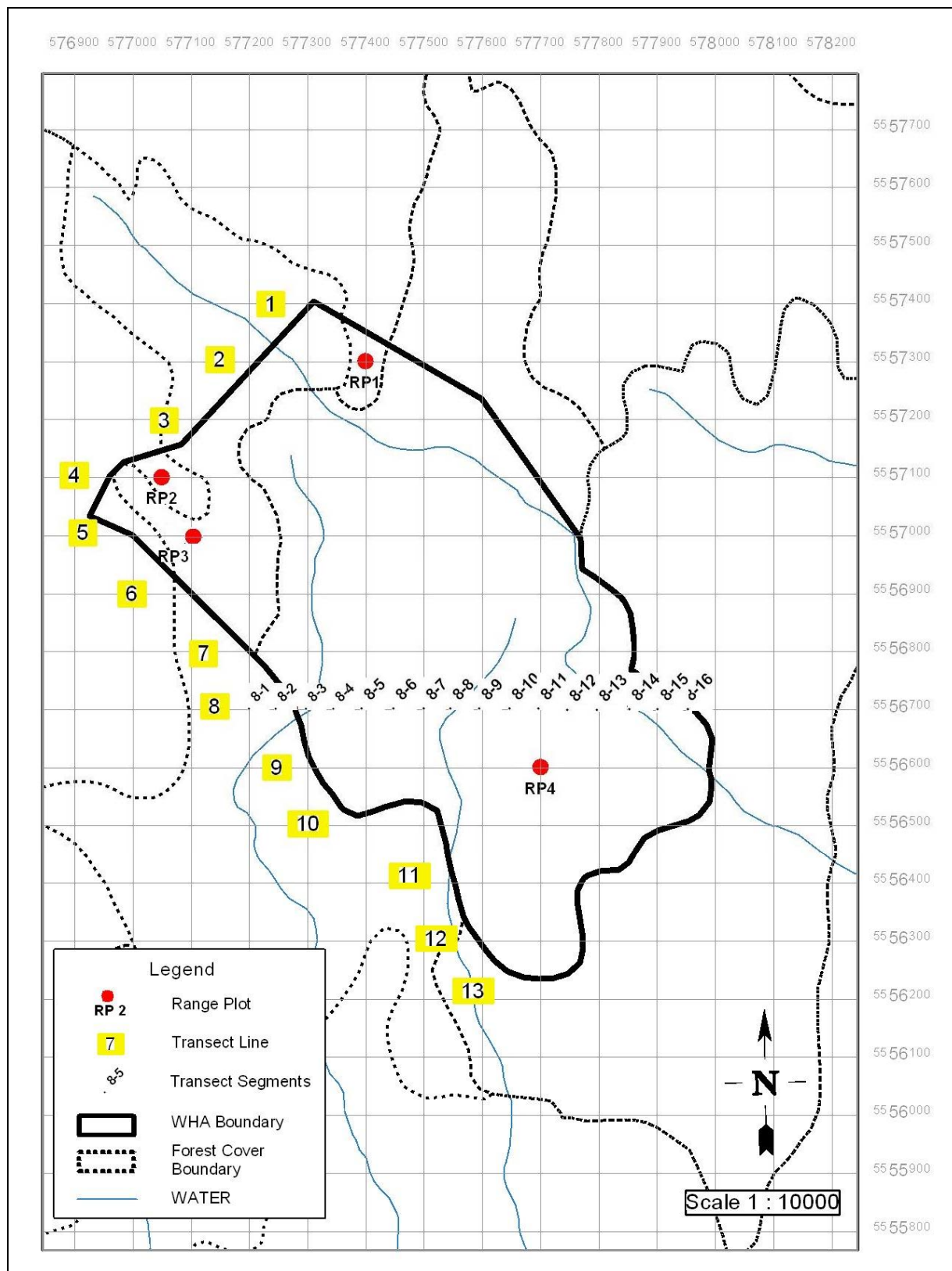


Figure 3. Example of badger WHA map with forest cover polygon lines, 100 m X 100 m grid overlay, transect segments and range plot locations. Transects extend to the first 100-m grid intersections outside of the WHA boundary.

*Criteria for Action*

A lack of recent badger burrows would result in a Not Functional rating unless (where applicable) there was a high level of recent ground squirrel activity or a sighting of a female or family group within the previous 6 years. If burrows are damaged or if there is no to limited evidence of recent activity within a WHA, this would suggest the need for increased assessment and implementation of conservation or recovery activities (Hoodicoff 2006).

## 5.2.2 Adjacency of Burrows to Highways

*Purpose*

To evaluate the distribution of badger burrows with respect to adjacent roads, for WHAs which directly abut a paved highway or its right-of-way. This analysis supplements other roadkill-risk indicators and is aimed at determining whether burrows within the WHA are disproportionately close to the highway. It assumes that badgers using burrows in close proximity to roads are at greater risk of vehicle collision than those farther away. Badger activity within an arbitrary distance of 200 m from the road or road right-of-way (depending on the WHA boundary) is compared to activity elsewhere in the WHA.

*Operational Requirements*

See Section 5.2.1: Badger and Ground Squirrel Burrow Densities.

*Office Procedures*

See Section 5.2.1: Badger and Ground Squirrel Burrow Densities.

*Field Procedures*

Data on badger burrow locations are drawn from sampling on transects as per Section 5.2.1 Badger and Ground Squirrel Burrow Densities. In addition, notes on off-transect badger burrow locations within 200 m of the road or right-of-way should be made opportunistically while walking between transects.

*Sampling Frequency*

See Section 5.2.1: Badger and Ground Squirrel Burrow Densities.

*Criteria for Action*

Combining all transects, if the proportion of 50-m segments having badger burrows (recent or older) is greater within 200 m of the highway or right-of-way than elsewhere in the WHA, badgers in the WHA will be considered to be at risk. This rating is also appropriate if opportunistic observations indicate concentrated badger activity in close proximity to the highway. Relative risk should be determined in the context of other roadkill-risk indicators, including road density, traffic volume, and number of road mortalities. See Section 5.1.3 for potential actions.

## 5.2.3 Range Status

*Purpose*

To evaluate trends in range status over time using 5 indicators (species composition, community structure, hydrologic and nutrient cycling (litter estimates), site stability and weed presence) and to provide an estimate of change in percent cover by shrub and overstory layer over time. Indicators were chosen based on grassland status assessments developed in

Alberta and British Columbia (Adams et al. 2005, Wikeem and Wikeem 2005). Collected at many sites over time, the data may be used to understand the relationship between forest cover type, range status and badger density. If the habitat requirements of local prey species become better known, the data may have predictive value in estimating prey availability.

#### *Operational Requirements*

- General knowledge of grass, forb, shrub and tree identification.
- Range status data form and database template
- High-visibility vest
- Hand-held GPS
- Map of site and range plot locations
- Digital camera
- Waterproof notebook
- Pens, pencils
- Compass
- Flexible measuring tape (30 m)
- Daubenmire frame (0.2 m X 0.5 m)
- Litter frame (0.5 m x 0.5 m)
- Litter estimate photographs
- Galvanized 12" stakes
- Brightly colored 1 " washers (spray-painted)
- Hammer

#### *Office Procedures*

1. Using GIS, identify forest cover types and overlay a 100 m X 100 grid (Figure 3).
2. Within each forest cover polygon, establish a range plot at the widest point of the forest cover polygon within the WHA (Figure 3). Plots are established at an intersection of a 100 m X 100 m grid, unless the WHA is too narrow to accomplish a 30 m transect from that point. If necessary, because of a small forest cover polygon, establish the plot elsewhere on the transect (i.e. not on the grid intersection; see RP#2 in Figure 3).
3. Print blank range status sheets on waterproof paper (Appendix 4).
4. Ensure that you have the most recent blank database for entering standardized data. A blank database has been created that is consistent with the Wildlife Species Inventory Program (<http://srmwww.gov.bc.ca/wildlife/wsi/index.htm>).

#### *Field Procedures*

At each site, data will be collected on ecological status, community structure, litter cover and distribution, site stability, noxious weeds and grazing intensity. These data can be used in a range status scoring system to assign a numerical score to each plot. Scoring systems have been developed by Alberta Sustainable Resource Development for that province (Appendix 5) and the Grasslands Conservation Council (GCC) for the Nicola Valley (Appendix 6). However, regional norms must be considered, particularly for litter, as there can be wide variation in litter volumes in different regions. The GCC is preparing other regional grassland health assessment manuals (e.g. Wikeem and Wikeem in prep.). If a regional manual is available for your region, complete it. If not, complete the Alberta form. In either case, be sure to record the raw data (not just scores) in the attached data form (Appendix 4) and database, so that comparisons can be made between data collected under different scoring regimes.

Fieldwork should follow these standards:

1. Conduct fieldwork between May and July.

2. Establish a permanent plot by pounding a metal nail into the ground with a brightly colored washer at the pre-established location. Record the location using a GPS unit. If possible in the field, determine the site series of the plot using regional guidebooks (Lloyd et al. 1990, Braumandl et al. 1992, Steen and Coupé 1998).
3. From the plot marker, take 1 photograph (landscape view) at 1 m off the ground to the north and 1 to the south. These should be labeled with the site name, date, and range plot number and inserted into the database. These will provide a visual indication of possible in-growth and/or grazing pressure over time.
4. Complete a plant species composition quadrat (0.1 m<sup>2</sup>) nested in 0.25-m<sup>2</sup> litter quadrats every 5 m along the 30-m transect, for a total of 6 sampling sites. In each plant composition quadrat estimate percent cover of the 3 most abundant grasses, forbs, shrubs and noxious weeds (if any). Also estimate percent cover of bare soil, bryophytes (mosses and lichens) and litter. Transect orientation is not important but should be consistent among polygons.
5. In the plant species composition quadrats record density distribution of noxious weeds (if any) using the guidelines in Appendix 7.
6. Based on the plant species composition data, assess if the plant community is native (it is modified if greater than 70% of the species are non-native). Include all non-native species in this assessment, i.e. not only noxious weeds.
7. In the plant species composition quadrats record percent cover of human-caused bare soil (e.g. caused by cattle grazing). Make notes about site stability, such as soil rutting, rills and pedestals (Appendix 8).
8. Observe the plant community structure. Each plant community has a characteristic number of life form layers (e.g. tall grass, low forb, tall forb, shrub). For example, trampling or excessive shading can reduce the moss and lichen layer or browsing can eliminate the shrub layer. Insect and drought impacts should not be considered. Record missing layers accordingly.
9. At each plant species composition quadrat, overlay a 0.5 m x 0.5 m frame to estimate litter. Litter is the plant residue left over from the previous years' production. Use visual litter estimate references provided by Wikeem and Wikeem (2005) and Adams et al. (2005). Report amounts in kg/ha.
10. In an 11.28-m radius plot (400 m<sup>2</sup>) centered on the transect start point, record grazing intensity at the plot using the categories (U / U-L / L / L-M / M / M-H / H) where U = ungrazed and L, M, H = low, medium, high grazing levels.
11. Record the observed utilization of shrubs and grasses in the 400-m<sup>2</sup> plot.
12. Also within the 400-m<sup>2</sup> plot, follow the procedures described in "Field Manual for Describing Terrestrial Ecosystems" (Ministry of Environment, Lands and Parks and Ministry of Forests 1998) to estimate percent cover for total layer and individual species within each layer and sublayers, if present, restricting sampling to the A, B1 and B2 canopy layers. Note the presence or absence of forest in-growth.

### *Sampling Frequency*

This indicator is considered a moderate priority (Hoodicoff 2006) and we propose it be conducted every 6 years, since badgers are able to co-exist with many forms of minor disturbance. Plots should be re-sampled if significant disturbance occurs on-site, such as fire or forest harvesting.

### *Criteria for Action*

A change in range status which coincides with a decline in badger and ground squirrel burrow counts may indicate the need to examine range management within the WHA (e.g. alter grazing

intensity or duration). Ecosystem restoration and invasive weed control may also be required to revitalize range health.

## 5.2.4 Presence of Family Groups

### *Purpose*

To record the presence of possible maternal badger burrows or family groups and to compare trends over time. Observation of a maternal burrow or family group suggests that the WHA is highly functional for badgers.

### *Operational Requirements*

- Access to regional badger sighting reporting lines (information and contacts are available on the *jeffersonii* Badger Recovery website).
- List of range and forestry tenure holders within WHA.
- List of potential ministry contacts (MoFR, MoE) who may be aware of badger family groups in the area.

### *Office Procedures*

1. Review regional sightings databases to determine the number of maternal burrows or family group sightings within the WHA. Contact range and tenure holders, and ministry contacts to determine if they have observed any unrecorded family groups. At the same time, ask if they have observed any roadkills within 3 km of the WHA. Once these stakeholders are identified, it would be efficient to ask that they submit any sightings to the reporting lines.
2. Enter all badger family group locations within the WHA in the database. A separate worksheet is available for maternal burrow locations.

### *Field Procedures*

At all times when within the WHA, stay observant for maternal dens or family groups. If a maternal burrow is found, record the GPS coordinates for the location.

### *Sampling Frequency*

We consider this indicator to be a high priority. Field-based searches will coincide with burrow counts which are to be conducted every 2 years. Sightings databases should also be reviewed every 2 years, updating with all data collected since last summarized for a particular WHA.

### *Criteria for Action:*

The confirmed use of a WHA by a family group increases the functionality rating to the highest level for 6 years, if the density of recent badger burrows is stable to positive or if there is a high density of recent ground squirrel burrows (where applicable; Figure 1). However, it will likely be relatively rare to discover maternal burrows or get sightings of family groups within the WHA, so the lack of such sign does not necessarily require management action.

## 5.3 Level 3: Effectiveness Indicators Requiring High Effort (Intensive)

### 5.3.1 Approaches

Erickson et al. (2005) recommend that monitoring protocols requiring intensive effort be developed on an as-needed basis. Intensive evaluations (DNA hair snagging, remote cameras, radiotelemetry) will likely require cooperation with researchers, graduate students and recovery teams with funding from a variety of cooperative sources. Detailed methods will thus depend upon the objectives of the particular study. However, the information gleaned will be useful for WHA effectiveness evaluations. In particular, the use of high-effort indicators will be most appropriate where low- and moderate-effort indicators suggest unsatisfactory effectiveness ratings (3 or lower).

### 5.3.2 Number of Badgers Using WHA, Presence of Female or Family Group, and Frequency of Burrow Use

The indicators selected by Hoodicoff (2006) for intensive evaluations, including number of badgers using WHA, presence of female or family group, and frequency of burrow use, all require evaluation by hair snagging for DNA. In addition, individual genotyping can be used to determine if there are matches between roadkilled individuals and those using WHAs. Techniques developed for collecting and analyzing badger hair samples for DNA are summarized in Hoodicoff and Packham (2006).

These 3 indicators (frequency of burrow use, number of badgers using WHA, and presence of female or family group) are considered together, as the office and field methods are the same for all indicators.

#### *Operational Requirements*

- Pinned knaplock hair snags
- Leather gloves
- Paper envelopes
- Pens, pencils
- Hand-held GPS
- High-visibility vest
- Access to DNA lab (e.g. Wildlife Genetics International, Nelson, BC)
- Access to individual genotyping collected through regional analysis of roadkilled badgers (contacts are available on the *jeffersonii* Badger Recovery website at [www.badgers.bc.ca](http://www.badgers.bc.ca))
- Excel database to record location, date, and DNA results
- Map of all proposed hair capture sites to ensure efficient travel between sites.
- Alternatively (or additionally), access to local badger radiotelemetry database.

#### *Office Procedures*

1. Prepare a layout of all sites that are planned for sampling. Depending upon the study design, these may be both inside and outside of the WHA.
2. Record all locations of snags, dates checked, samples collected, and DNA results.
3. Compare genotypes of roadkilled individuals to those collected at the WHA.
4. Alternatively (or additionally), use the radiotelemetry database to plot locations of all female badgers, to see if any fall within WHA boundaries.

### *Field Procedures*

Follow procedures for setting hair snags and collecting hair as identified in Hoodicoff and Packham (2006). Data regarding the presence of females or family groups and the frequency of burrow use may also be gained using remote digital cameras. Methods would need to be developed on a site-specific basis. Other data may be gained opportunistically via radiotelemetry-based studies that may involve badgers using WHAs.

### *Sampling Frequency*

This group of indicators is considered high priority because of the valuable information it provides about badger use of WHAs. However, it requires multiple visits to a site (every 4 to 6 days through field season) and lab analysis. Sampling frequency will likely depend upon the ability to cooperate with other initiatives, but it is recommended that all WHAs within 1 region be sampled within the same field season to maximize efficiency and comparability between WHAs.

### *Criteria for Action*

DNA techniques provide a tool to confirm the presence of family groups, the number of badgers using a WHA, and frequency of burrow use. The confirmed use of a WHA by a female badger to rear kits increases the functionality rating to the highest level for 6 years, if the density of recent badger burrows is stable to positive or if there is a high density of recent ground squirrel burrows (where applicable; Figure 1). The confirmed use of habitat by badgers (i.e. at least 1 badger identified) provides a quantitative indicator of WHA effectiveness that can be compared between years and sites, and ensures a functionality rating greater than Not Functional (except in some cases of downward trends in burrow occupancy; see Table 2). The frequency of individual burrows being used provides an indication that the habitat is still suitable and that the badgers are not being disturbed at that burrow site. If multiple individual burrows are not being used at least annually within a WHA, it may indicate the need to implement more in-depth surveys to determine the reason for non-use. However, it is important to note that the absence of badgers within a WHA may be a function of low population density in the region, regardless of the habitat quality within the WHA. DNA sampling allows researchers to cross-reference roadkilled badgers against those recorded through WHA hair snags, allowing a more precise evaluation of roadkill risk for a WHA.

## 5.4 Time Requirements for Monitoring Tasks

Estimated times required to complete the monitoring program for indicators requiring low or moderate effort (routine or extensive) are listed below.

- GIS work (permanent habitat loss, change in canopy closure, road density): 50 hr for all WHAs in region, assuming ~10 WHAs (incremental cost or benefit of additional or fewer WHAs is minimal)
- road mortality: 8 hr for all WHAs in region, assuming base mapping is already in place
- traffic volume: 16 hr for all WHAs in region
- rapid on-site assessment: ~2 hr per WHA (depending on WHA size), plus travel time
- badger and ground squirrel burrow surveys and range status plots (done together): 0.5 hr/ha, including office prep, field work and data entry (not including travel time)
- adjacency of burrows to highway: 2 hr per WHA, assuming field work covered under item above
- presence of family groups: 2 hr to search sightings databases and contact tenure holders; field observations incidental to other field work (no incremental time requirement)

- data summary and effectiveness evaluation: 32 hr per site
- additional items such as review of methods and revisions to summary report add about 20% to the above.

Indicators identified as requiring high effort (intensive) have highly variable time requirements, depending upon the level of detail desired and the degree to which they can be achieved under existing research programs.

## 6.0 Reporting Requirements

A summary report of all findings should be prepared for each badger Wildlife Habitat Area and for each region every 6 years to coincide with completion of both the routine and extensive evaluations, which are on 2- or 6-year cycles. Ratings for functionality, risk and effectiveness should be provided, along with a rationale for such ratings. The summary report should identify relationships between habitat status and use (if these can be surmised), and recommended actions to maintain or improve the WHAs' functionality or reduce risk. Reports of more limited scope covering field-based measures should be completed biennially when field work occurs.

All data should be warehoused in a central location using a standardized database so that sites across the province can be compared.

## 7.0 Data Gaps and Challenges to Conservation

Badgers are challenging to conserve. They are wide-ranging carnivores, and much of their high-quality habitat is on private land (Newhouse and Kinley 2006, Weir et al. 2003). It is not clear which habitat conditions, and therefore which range and forestry practices, are most beneficial to badgers. This is due in part to regional differences in habitat selection, diet and behavior, which in turn make it difficult to design and interpret provincial monitoring and management standards. For example, preliminary observations suggest that in certain areas where Columbian ground squirrels are a primary food source, sites in poor range condition are often heavily used by badgers. The priority in any Crown land management should be ecosystem health, and overall species richness and diversity in grasslands have been found to decrease with heavy grazing (MacKenzie 2004). However, the example above does point to the difficulty in using habitat measures to evaluate the ability of WHAs to support badgers, particularly when comparing across regions. Data collected through regular WHA monitoring should begin to help address this gap.

While GIS data analysis is used extensively here as a tool to identify risks to WHAs, GIS data cannot replace regular site visits to determine the presence of badgers, and to identify changes to habitat, especially in areas close to human activities. GIS data are not always consistently available between regions, and may not be upgraded frequently enough to comply with the 6-year evaluation cycle outlined in this document.

Highway roadkill represents the main source of mortality, and it cannot be effectively mitigated by range and forestry practices. Significant losses of badger habitat and connectivity are also occurring on private land through housing and other recreational developments that are outside of the scope of land management under FRPA. While risks to badger conservation clearly exist, quantifying them in an empirical way is challenging. Thus, it is difficult to assign risk ratings with precision.

From the above, it is clear that it can often be difficult to explain either upward or downward trends in badger populations or WHA occupancy. However, monitoring badger WHAs does provide an excellent foundation for assessing regional trends and furthering our understanding of relationships between habitat conditions, management regimes, and badger and prey responses. Identifying site-specific needs for ecosystem restoration, roadkill mitigation, and other interventions will be valuable in conserving badgers in the province.

## 8.0 Literature Cited

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## Appendix 1. General Wildlife Measures Proposed for East Kootenay Badger Wildlife Habitat Areas, February, 2006<sup>5</sup>

### Badger Candidate Measures

#### *Access*

- Do not develop any new road access unless an exemption is provided by the delegated decision maker.
- No resource extraction or log hauling during the maternal period (1 May – 15 August).
- Close all newly established roads after resource extraction is completed.

#### *Harvesting and silviculture*

- Harvest as required to support ecological restoration. Reduce stocking densities (<75 stems/ha; target of 20 stems/ha) and free-to-grow requirements.
- Leave a selection of live and dead trees to maintain site ecology.
- Ensure forest activities to not disturb or damage important habitat features.

#### *Pesticides*

- Do not use pesticides unless an exemption is approved by the MOE Delegated Decision Maker. An exemption is not required for the treatment of noxious weeds and invasive plants provided the herbicide is applied by selective application and the herbicide is applied in a manner that does not result in drift to non-target species.
  - Where glyphosate is the active ingredient, the herbicide may be used up to 1 metre from the high water mark of any body of water.
  - Where the product used has an active ingredient other than glyphosate, the herbicide may be used up to 10 metres from the high water mark of any body of water.

#### *Range*

- Do not build infrastructure (e.g. fences and corrals) that disturbs or damages important habitat features.

### Appendix A (included as supporting information but not directly part of the GWMs)

Bodies of water include a) water in a watercourse such as a river, stream or creek; b) water in the basin of a lake, marsh or slough; c) marine or estuarine water; d) dry watercourse or temporary wetland that is either wet or dry; or e) water in a ditch but does not include human-made, self-contained water bodies (e.g., ponds and dugouts).

Selective Application means the application of a pesticide to individual plants so that the vegetation between the individual plants is not treated.

<sup>5</sup> T. Antifeau, MoE, Nelson, British Columbia, personal communication.

## Appendix 2: Proposed Method to Standardize the Observed Number of Recently Occupied Ground Squirrel or Badger Burrows in Relation to Survey Date

*N.B.: These proposed methods were developed specifically for the East Kootenay. They may require modification in other regions if badger or ground squirrel ecology differs significantly.*

We assume that the number of recent ground squirrel burrows will relate to date in a non-linear fashion. The number should increase rapidly following emergence from hibernation in early April but increase only slowly later in the summer because most activity then will be in burrows already used that year. The maximum number will be reached in early August, after which ground squirrels re-enter hibernation. In the absence of any data from which to surmise the details of this relationship, we assume that the relative number of recent ground squirrel burrows on any day prior to hibernation is proportional to the log of the difference between that day and the date of emergence. Mathematically this can be expressed as:

$$R_i = \log_{10}(t_i - t_0 + 10)$$

where:  $R_i$  = relative number of recent burrows on date  $t_i$

$\log_{10}$  = base 10 log

$t_i$  = date of survey or August 15 (assumed date by which all ground squirrels have entered hibernation), whichever is earlier

$t_0$  = April 1 (assumed date of emergence from hibernation)

10 = constant added so that  $R_i$  on 1 April = 1.000

This model results in a prediction that, in comparison to 1 April, there will be 1.5 times as many recently occupied ground squirrel burrows by 23 April and 2.2 times as many on 15 August and thereafter (Figure A1).

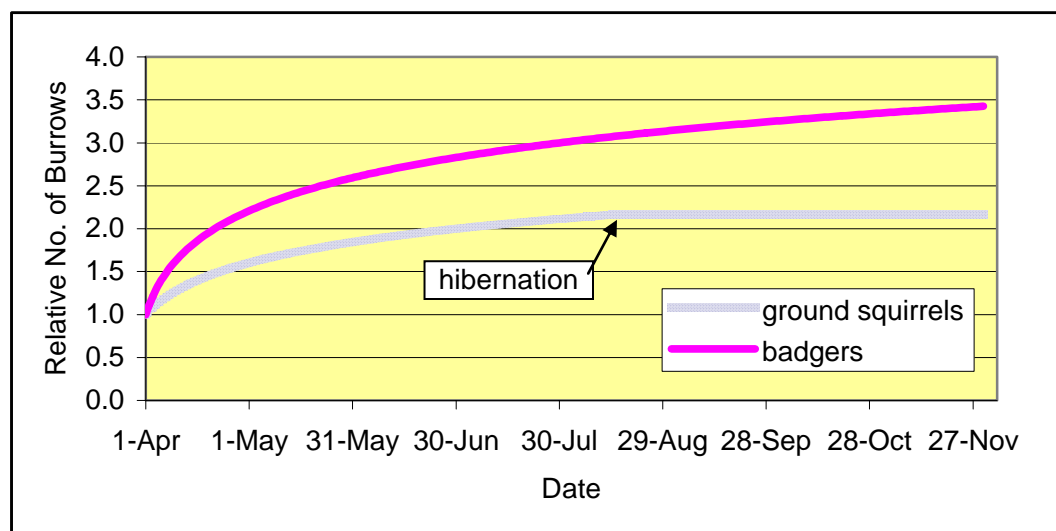


Figure A1. Assumed relationship between date of survey and relative number of recent burrows present.

While badgers are active year-round, we assume for the East Kootenay area that:

1. Snow cover and freeze-thaw activity will make badger burrows used prior to 31 March indistinguishable from burrows used prior to that calendar year.
2. Badger burrowing activity after 1 April will initially increase rapidly as ground squirrels emerge from hibernation.

3. Burrowing activity will continue to increase throughout the snow-free season. The rate and degree of increase will be greater for badgers than for ground squirrels because badgers are not sedentary and continually create new burrows in hunting for prey. However, the relationship between badger burrows and time will not be linear because there will be considerable re-use of foraging areas, and some of the existing burrows within them, throughout the summer.
4. This relationship holds true through 30 November, the approximate start date of permanent snow cover.

To model this relationship for badgers, we used the formula:

$$R_i = \log_5(t_i - t_0 + 5)$$

where:  $R_i$  = relative number of recent burrows on date  $t_i$   
 $\log_5$  = base 5 log (chosen arbitrarily to provide a steeper, higher curve than for ground squirrels)  
 $t_i$  = date of survey, up to 30 November  
 $t_0$  = 1 April  
 5 = constant added so that  $R_i$  on 1 April = 1.000

This model results in a prediction that, in comparison to 1 April, there will be 2.0 times as many recent badger burrows by 21 April and 3.4 times as many by 30 November (Figure A1).

To convert the observed number of recent burrows to the estimated number that would be present at the end of the season, based on the models above, the following formula applies:

$$P_{\max} = N_{\text{obs}} * R_{\max} / R_i$$

where:  $P_{\max}$  = predicted number of recent burrows at end of season (15 August and thereafter for ground squirrels or 30 November for badgers)  
 $N_{\text{obs}}$  = number of burrows observed on date  $i$   
 $R_{\max}$  = relative number of recent burrows on last day of season (greatest possible  $R_i$  from previous formulas, i.e. 2.164 for ground squirrels and 3.438 for badgers)  
 $R_i$  = relative number of recent burrows on survey date  $t_i$  (from previous formulas).

Thus,  $P_{\max}$  is a standardized or corrected measure of recent badger or ground squirrel burrow numbers, which can be compared among WHAs sampled on different dates or within a WHA among years (if sampling dates differ among years). The models are undoubtedly somewhat erroneous, and they have the potential to cause questionable results such as sometimes indicating that the number of recent burrows expected by season-end will be higher than the current number of total burrows. However, they approximate our best guess as to the temporal pattern and we are not aware of any data to validate or improve them. The alternative to using such models is to either assume that the number of burrows occupied in a calendar year does not change over the course of the snow-free season (certainly wrong), to sample all WHAs in all years on roughly the same date (logistically not possible), or to change the criteria from recent to total badger and ground squirrel burrows (which would result in long delays in detecting declines). Consequently, we recommend the adoption of these models for the East Kootenay area until data or professional judgments are available to improve them.

## Appendix 3. Geographic Information System (GIS) Resources

### **Forest Cover**

SOURCE: Ministry of Forests and Range

WEBSITE: <http://www.for.gov.bc.ca/hts/>

DATA: Forest cover data are obtained at district and regional levels and are linked with geographic data (base maps, ownership and administrative boundaries) to produce an inventory/database that provides information on the location, areal extent, physical characteristics, and condition of the forest. With the exception of managed forest units, timber inventories are not available for most private land.

### **Grassland Ecosystem Mapping**

SOURCE: Grassland Conservation Council of British Columbia (GCC 2004)

WEBSITE: <http://www.bcgrasslands.org/projects/conservation/mapping.htm>

DATA: Data coverages include grassland and open forest ecosystems, and historic grasslands alienated for agricultural and urban development that are available at 1:20,000 scale. Data were compiled using existing data and inventories (e.g., Forest Cover, Biogeoclimatic Zone, Range Act tenures). Historic grasslands lost to agriculture and urban development were assessed using historic MoFR range survey lines (generally dated from the 1940s and 1950s), air photos (generally dated from 1938 to early 1960s), and from interviews with individuals familiar with each forest district.

### **Terrain Resource Information Management (TRIM)**

SOURCE: Integrated Land Management Bureau (ILMB)

WEBSITE: [http://ilmbwww.gov.bc.ca/bmqs/trim/trim/trim\\_overview/trim\\_program.htm](http://ilmbwww.gov.bc.ca/bmqs/trim/trim/trim_overview/trim_program.htm)

DATA: TRIM data are available at 1:20,000 scale, and include Digital Elevation Model and contours at a 20-m interval, man-made features such as roads, buildings, fences, etc., as well as natural features such as streams, lakes, swamps, etc., and official place names.

### **Vegetation Resource Information (VRI)**

SOURCE: Ministry of Forests and Range

WEBSITE: <http://www.for.gov.bc.ca/hts/vri/>

DATA: VRI replaced Forest Cover data inventory, and are conducted by the private forest industry and forestry consultants on private and Crown land. Vegetation inventory is conducted first from air photo interpretation and other sources, and is followed by ground sampling to determine how much of a given characteristic is within the inventory area. VRI will be updated as human activities, such as logging, tree planting, right-of-way construction for highways and pipelines, or natural disturbances, such as fires, insects and windthrow, occur.

### **Other Resources**

Land Resource Data Warehouse (LRDW): <http://www.lrdw.ca/>

Base Map On-Line Store (ILMB): <http://ilmbwww.gov.bc.ca/bmqs/ecommerce-intro.html>

## Appendix 4. Range Status Data Form

Site: _____ Observer(s): _____ Date (y/m/d): _____							
Photo Number to N: _____ Photo Number to S: _____							
NAD 83 UTM Zone: _____ Easting: _____ Northing: _____							
Site Series: _____ Special Comments: _____							
<b>Daubenmire Frame</b>							
	1	2	3	4	5	6	<b>Average</b>
Grass 1							
Grass 2							
Grass 3							
Forb 1							
Forb 2							
Forb 3							
Shrub 1							
Shrub 2							
Shrub 3							
Weed 1*							
Weed 2*							
Weed 3*							
Weed dens.**							
Bare soil							
Bare soil2***							
Bryo							
Litter							
Native or Modified? (are greater than 70% of species non-native?): _____							
Community Structure (list the layers that have been significantly altered by management): _____							
Litter Cover and Distribution (use reference photos):							
	1	2	3	4	5	6	<b>Average</b>
litter estimate							
Grazing Intensity (circle one): U / U-L / L / L-M / M / M-H / H							
Observed Grass Utilization: _____ %							
Observed Shrub Utilization: _____ %							
<b>A1 Layer Cover</b>	Species 1	%	Species 2	%	Species 3	%	Total %
<b>B1 Layer Cover</b>	Species 1	%	Species 2	%	Species 3	%	Total %
<b>B2 Layer Cover</b>	Species 1	%	Species 2	%	Species 3	%	Total %
Forest Ingrowth/Encroachment (note if present): _____							
* Record cover of noxious weeds here even if they don't make up one of the three top species							
** Weed density distribution category							
*** Record cover of human-caused bare soil; make notes on site stability							






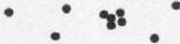




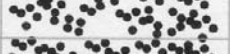


## Appendix 5. Alberta Range Health Assessment Form (Adams et al. 2005)

Grassland Range Health Assessment - Score Sheet								
Site _____		Observer _____		Date _____				
LSD _____	Quarter _____	Section _____	Township _____	Range _____	Meridian _____	Photo # _____		
GPS Coord (NAD 83) Lat. _____		Long. _____		Estimated forage production _____		lb/ac or kg/ha		
Special Observations (climate, changes in management) _____								
<b>Scoring</b> (circle appropriate values and add their sum to the SCORE box):								
<b>1. What kind of plants are on the site? What is the plant community?</b>								
<b>Dominant species</b>								
Grasses & Grasslikes	% Cover	Forbs	% Cover	Shrubs	% Cover	Trees	% Cover	
Community Type _____								
<b>Ecological Status</b> (choose 1A or 1B)							Score	
1A	Native Grassland:	24	16	8	0	Comments		
1B	Modified Grassland:	9	5	0	-			
<b>2. Are the expected plant layers present?</b>								
<b>Community Structure</b>	6	4	2	0	Comments		Score	
<b>3. Does the site retain moisture?</b>								
<b>Litter cover and Distribution</b>	15	8	0	-	Comments		Score	
<b>4. Is there accelerated soil erosion? Site Normally (circle) Stable / Unstable</b>								
<b>Site Stability</b>							Score	
4.1	Erosion:	6	4	2	0	Comments • Human caused bare soil (%) _____ Moss & lichen cover (%) _____		
4.2	Bare Soil:	3	2	1	0			
<b>5. Are noxious weeds present? (score using density distribution guide on back page)</b>								
<b>Noxious Weeds</b>				Dominant species	% Cover	Density Dist.	Comments	Score
5.1	Canopy Cover	3	2	1	0			
5.2	Density Distribution	3	2	1	0			
<b>Grazing Intensity</b> (est. Long Term (circle)): U / U-L / L / L-M / M / M-H / H								
<b>Trend</b> (apparent - circle): Upward / Downward / Stable / Unknown								
<b>Site Score</b> (total all scores) <input style="width: 50px;" type="text"/>								
<b>Observed Utilization</b> _____ %								
(Site Score ÷ 60 x 100) = Percent Health Rating ( _____ ÷ 60 x 100) = _____ % <b>Healthy = 75-100%; Healthy with problems = 50-74%; Unhealthy &lt; 50%</b>								

Appendix 6. Grassland Assessment Score Sheet for the Nicola Valley (Wikeem and Wikeem 2005)

<b>Site:</b> _____ <b>Observer:</b> _____ <b>Date:</b> _____						
<b>GPS Location:</b> N _____ E _____ <b>Slope:</b> _____ <b>Aspect:</b> _____						
<b>Elevation:</b> _____ <b>Current Uses (Circle):</b> Livestock Recreation Wildlife Other						
<b>Management Objective(s)</b> _____						
<b>Comments (weather, management changes)</b> _____						
<b>Scoring (Circle appropriate value and add scores in score boxes)</b>						
<b>1. Plant Community Composition Community Type:</b> _____						
<b>Key Bunchgrasses:</b> 40 25 10 0				<b>Comments:</b>	<b>Score</b>	
<b>2. Plant Community Structure</b>						
<b>Expected Layers:</b> 10 6 2 0				<b>Comments:</b>	<b>Score</b>	
<b>3. Nutrient and Hydrological Cycling</b>						
<b>Amount and Distribution of Litter</b>				<b>Comments:</b>	<b>Score</b>	
<b>Litter Mass:</b> 12 15 8 0						
<b>Litter Cover:</b> 10 5 0						
<b>4. Site Stability Site Normally (circle):</b> Stable / Unstable						
<b>Site Stability</b>				<b>Comments:</b>	<b>Score</b>	
<b>Erosion:</b> 9 6 3 0						
<b>Bare Soil:</b> 6 4 2 0						
<b>5. Invasive Plants (see list)</b>						
<b>Invasive Plants</b>		<b>Species</b>	<b>% Cover</b>	<b>Distribution</b>	<b>Comments:</b>	<b>core</b>
<b>Canopy Cover:</b> 5 3 1 0						
<b>Distribution:</b> 5 3 1 0						
<b>Invasive Plants Near Site</b>		<b>Species:</b>		<b>Comments:</b>		
<b>Site Score (Sum All Scores)</b>						
<b>Grassland Status (Circle):</b> Reference: 75-100; Slightly Altered: 51-75; Moderately Altered: 25-50; Greatly Altered: <25						
<b>Apparent Trend (Circle):</b> Upward / Downward / Stable / Unknown						

## Appendix 7. Weed Density Distribution Guide (Adams et al. 2005)

Density Distribution				
Class	Description of abundance in polygon	Distribution	Weeds Score	Regrowth Score
0	None		3	2
1	Rare		2	
2	A few sporadically occurring individual plants			
3	A single patch		1	
4	A single patch plus a few sporadically occurring plants			
5	Several sporadically occurring plants			
6	A single patch plus several sporadically occurring plants		0	1
7	A few patches			
8	A few patches plus several sporadically occurring plants		0	
9	Several well spaced patches			
10	Continuous uniform occurrences of well spaced plants			
11	Continuous occurrence of plants with a few gaps in the distribution		0	
12	Continuous dense occurrence of plants			
13	Continuous occurrence of plants with a distinct linear edge in the polygon			

Appendix 8. Examples of Site Stability Problems (Wikeem and Wikeem 2005)

