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FOREST AND RANGE EVALUATION PROGRAM

July 2009

Effectiveness Monitoring of Badger Wildlife Habitat areas: Summary of Current Areas and Recommendations for Developing and Applying Protocols

Prepared by Trevor A. Kinley
Sylvan Consulting Ltd.
July 2009

Badger wildlife habitat: Photo by Trevor Kinley

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MINISTRY OF FORESTS AND RANGE
FOREST AND RANGE EVALUATION PROGRAM

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Management of forest and range resources is a complex process that often involves the balancing of ecological, social, and economic considerations. This evaluation report represents one facet of this process. Based on monitoring data and analysis, the authors offer the following recommendations to those who develop and implement forest and range management policy, plans, and practices.

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EXECUTIVE SUMMARY

The subspecies of American badger (*Taxidea taxus jeffersonii*) present in British Columbia is endangered. The *Forest and Range Practices Act* (*FRPA*) allows the creation of Wildlife Habitat Areas (WHAs) for badgers or other identified wildlife. As of January 2009, 18 WHAs for badgers had been created and 20 more are proposed. These collectively cover 2778 ha and range from 1 ha to more than 300 ha each. Also pursuant to FRPA, General Wildlife Measures (GWMs) have been created to manage forest and range-related activities within WHAs. A framework document that identifies key monitoring questions for WHAs was written in 2006. These questions address badger habitat, disturbance, badger use of the WHA, reproduction within the WHA, and highway mortality near the WHA. From this framework, a protocol for monitoring WHAs was developed and updated in 2007. It includes measures of WHA functionality (high, moderate, not) and risk to WHA viability (low to nil, long-term, immediate). When combined, these measures yield an effectiveness rating for the WHA of 1 to 5, with 5 being "most effective." Most of the methods depend on an assessment of trends across successive evaluations. As of January 2009, nine WHAs, or proposed WHAs, had been evaluated to provide baseline information, but no second evaluations have been conducted. Despite the lack of temporal trend data, preliminary effectiveness ratings were determined from the baseline evaluations. For all nine WHAs, functionality was rated as "moderate" to "high," with risks assessed as generally "low to nil" or "long-term." Effectiveness ratings were 4 or 5 out of 5.

The following activities are recommended for the ongoing management and evaluation of WHAs.

Continue monitoring WHAs to create baselines for those lacking them and then determine trends for each WHA.

1. Re-evaluate the use of range-condition monitoring. The current methods do not provide direct indices of prey abundance, yet this is the mechanism by which range condition would potentially influence the value of WHAs for badgers. Where ground squirrels constitute the main prey, range condition may be of little relevance. Where other prey species predominate, more direct measures of their abundance (animal sign or specific habitat indicators) should be developed where possible to replace or at least supplement general range condition monitoring. In some cases, this may be as simple as adding marmot burrows or pocket gopher mounds to the sign monitored on burrow transects.
2. Burrow density is a key factor in determining WHA functionality. Assess the regional and provincial densities of badger and ground squirrel burrows that will qualify as "high density." In addition, test the assumptions used to standardize the expected number of recent burrows at season-end in relation to survey date.
3. Trends in the abundance of badger and prey burrows are amenable to simple statistical analyses such as t-tests or Wilcoxon tests.
   Before conducting analyses, determine (with the aid of a statistician) whether contiguous transect segments are independent, and at what spatial scale.
4. Decide how much effort to allocate to comparisons within WHAs (over time or space) in relation to comparisons between WHAs (to rank relative effectiveness) or between WHAs and controls (to determine whether WHAs in the aggregate serve their intended purpose). Again, professional statistical advice would help to achieve an appropriate sampling and analysis design.
5. To reduce costs, assign each member of the two-person field crew to separate transects (with radio or cell phone contact for safety), and replace general range monitoring with specific tests for key prey species where possible.

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1. BACKGROUND

1.1 *Badger Status*

American badgers (*Taxidea taxus*) in British Columbia are of the *jeffersonii* subspecies, which is provincially red-listed with a G5S1 ranking (Conservation Data Centre 2006). With a Canadian distribution only in British Columbia and less than 350 breeding adults (Conservation Data Centre 2006), this subspecies is nationally endangered (COSEWIC 2006).

Badgers[1] can be opportunistic in their feeding habits, killing or scavenging all classes of vertebrates and some invertebrates. However, across their range, they are primarily predators of fossorial or semi-fossorial rodents, such as ground squirrels, pocket gophers, marmots, and voles (Lindzey 1982; Messick 1987; Kinley and Newhouse 2008). Although various habitats are used, badgers prefer the open cover types, such as grasslands, open forests, fields, cutblocks, roadside verges, and the alpine, in which their main prey typically occurs. Soil types within these areas are variable; any limitations probably relate to soils whose excessive coarse-fragment content or shallow depth reduces the burrowing ability of prey. Past negative influences and current threats to badger are varied, but two of the most significant are road mortality and the loss of habitat to development or the encroachment of conifers into former grassland and open forest areas (*jeffersonii* Badger Recovery Team 2008).

1.2 *Wildlife Habitat Area Goals, Characteristics, and Establishment*

Under the *Forest and Range Practices Act* (*FRPA*), four habitat management practices have potential direct relevance to badger conservation: wildlife habitat areas (WHAs), specified areas, general wildlife measures (GWMs), and wildlife habitat features. To date, badger conservation has been addressed through the designation of WHAs, along with the associated GWMs that guide activities falling under the control of the Ministry of Forests and Range within the WHAs.

The *Accounts and Measures for Managing Identified Wildlife* includes an account for the badger (Ministry of Water, Land and Air Protection 2004a). The intent of badger WHAs is to protect important habitat, such as maternal dens or other concentrations of burrows, and sites with abundant prey or highly suitable soils (Ministry of Water, Land and Air Protection 2004a). The accounts and measures document provides broad guidance as to desired characteristics, as well as rough direction on size (“generally 2 – 100 ha”) and boundaries (“use soil or geologic boundaries wherever possible”). Procedures for the legal establishment of WHAs have also been identified (Ministry of Water, Land and Air Protection 2004b); however, no firm requirements exist regarding WHA size, vegetation type, density of burrows, or amount of badger activity. In practice, the location, area, layout, and other WHA characteristics are left largely to the discretion of the staff or consultants who nominate or review candidate areas. This allows badger habitat use, distribution, and abundance to be considered along with local land-tenure patterns. In some cases, badger burrows are widely distributed across continuously suitable soils or other habitat features, so WHA boundaries are simply established along the most visible landmarks (roads, fencelines, ridgelines, major timber type changes, etc.) to keep them to a manageable size. In other cases, badger activity is restricted to specific biophysical features with obvious natural boundaries, such as meadows, old cutblocks, or open hillsides. Low levels of badger activity in regions with little overall badger activity on Crown land may be sufficient to justify a WHA designation, but this may not be the case in regions with a greater density of badgers. Those WHAs approved or under consideration vary in size by roughly two orders of magnitude, and also fall within landscapes having either frequent stand-maintaining fires (natural disturbance type 4; NDT4) or frequent stand-initiating fires (NDT3).

Four goals for GWMs are set out in Ministry of Water, Land and Air Protection (2004a). These are (1) maintain important habitat features, including sufficient structure / litter to provide hiding cover, open- or non-forested land, grasslands in a range of seral stages, friable soils, and prey; (2) control forest encroachment and in-growth; (3) manage livestock grazing to maintain suitable habitat for prey species; and (4) minimize disturbance during the breeding season. These goals translate into specific measures relating to access, forestry, pesticides, and range (Table 1). Other guidance is listed as considerations rather than formal measures, including reducing stocking in NDT3 sites, protecting prey, and restricting off-road vehicle use.

1 “Badger” is used in this report to refer to *Taxidea taxus jeffersonii*, unless otherwise indicated.

Table 1. General Wildlife Measures (GWMs) listed for badger WHAs in Accounts and Measures for Managing Identified Wildlife (Ministry of Water, Land and Air Protection 2004a).

Category	Measures
Access	• Do not develop any new road access.
	• Restrict access to active maternal areas between 1 May and 15 August.
	• Close all established roads after resource extraction is completed.
Harvesting and Silviculture	• Harvest as required to support ecological restoration. Reduce stocking densities (< 75 stems per hectare; target of 20 stems per hectare) and free-to-grow requirements.
	• Leave a selection of live and dead trees to maintain site ecology.
Pesticides Range	• Do not use pesticides.[a]
	• Do not place livestock attractants in WHA.
	• Manage livestock grazing to ensure proper conditions (seral and structural stages) for prey species.

a This wording from the original document does not indicate whether it was intended to apply to herbicides, insecticides, rodenticides, or all three.

Orders for specific WHAs can provide guidance or requirements that vary from the general measures identified above. For example, the order for seven WHAs in the Rocky Mountain Forest District (Trumpy 2006) does not prohibit the use of livestock attractants or discuss range conditions for prey species; however, it does prohibit the construction of corrals and fences during the maternal period. The order also permits selective pesticide use for control of invasive plants. These variances allow actions that maintain badger foraging opportunities (e.g., Columbian ground squirrel habitat should be maintained both by grazing and weed control), while recognizing previous obligations to range tenure holders. The order for a series of WHAs in the 100 Mile House Forest District (Hesketh 2008) does not seasonally restrict access near maternal dens, exempts the use of herbicides for weed control from the general prohibition on pesticide use, includes a prohibition on developing infrastructure

Table 2. Wildlife Habitat Areas established for badgers in British Columbia as of January 2009 (source: http://www.env.gov.bc.ca/wld/frpa/iwms/wha.html*).*

Number	Name	Forest District	Area (ha)
4-088	Tata Creek Airport North	Rocky Mountain	235.8
4-089	Lost Dog South	Rocky Mountain	145.4
4-090	Tata Creek Airport South	Rocky Mountain	225.3
4-091	McGinty Lake	Rocky Mountain	111.6
4-092	North Kikomun Creek	Rocky Mountain	26.6
4-102	Fir Mountain	Rocky Mountain	59.0
4-103	Johnson Lake	Rocky Mountain	9.4
5-074	China Lake	100 Mile House	85.0
5-075	Augustine	100 Mile House	38.9
5-076	1200 Road	100 Mile House	38.3
5-077	Windmill	100 Mile House	99.4
5-078	Alberta Lake West	100 Mile House	138.4
5-079	Alberta Lake East	100 Mile House	55.2
5-080	Pollard Lake	100 Mile House	73.7
5-081	River Lakes	100 Mile House	123.3
5-082	McKinley Lakes	100 Mile House	89.7
5-084	Hutchison Lake	100 Mile House	71.8
5-085	Komori	100 Mile House	47.5

Table 3. Proposed Wildlife Habitat Areas for badgers in British Columbia; approval pending, as of January 2009 (sources: R. Weir, Artemis Wildlife Consultants; T. Kinley, Sylvan Consulting Ltd.).

Proposed	Name	Forest District	Area (ha)
2006	TFL 35_1	Kamloops	2
2006	TFL 35_2	Kamloops	25
2006	TFL 35_3	Kamloops	5
2006	Sheep Creek	Rocky Mountain	36.8
2006	West Yahk River	Kootenay Lake	4.1
2007	Trapping Creek	Arrow Boundary	28.8
2007	Beaverdell Creek	Arrow Boundary	1.0
2007	Brunnette Lake	Okanagan Shuswap	1.9
2007	Allendale Lake	Okanagan Shuswap	1.9
2007	Badger Flats	Kamloops	17.2
2007	Truda Lake	Kamloops	3.5
2007	Sawmill 41	Kamloops	9.6
2007	Strachan Meadows	Kamloops	74.3
2007	City Pasture Potholes	Rocky Mountain	144
2007	Lot 8104	Rocky Mountain	45
2007	Skookumchuck North	Rocky Mountain	189
2007	Sommerfeldt-Airport	Rocky Mountain	32
2007	St. Mary's Pipeline	Rocky Mountain	312
2008	Westwold – West	Okanagan Shuswap	36
2008	Westwold – East	Okanagan Shuswap	135

for livestock except as specified, and provides specific direction on range condition targets. It therefore includes guidelines specific to the local situation (e.g., heavy grazing is expected to reduce the diversity and abundance of some of the small mammals used as prey in that area), and also defines "forest encroachment" and "livestock attractant." Provision is made in both cases for further exemptions from the orders.

As of January 2009, 18 approved badger WHAs had been established. These areas cover 1674.3 ha (Table 2), slightly over half of which is in the Rocky Mountain Forest District. In addition, seven WHAs are proposed for the Kamloops Forest District, four for the Okanagan Shuswap Forest District, two for the Arrow Boundary Forest District, one for the Kootenay Lake Forest District, and six for the Rocky Mountain Forest District. These 20 proposals total about 1104 ha (Table 3). Additional WHA proposals are expected from the 100 Mile House Forest District in fall 2009 (R. Packham, Ministry of Environment, pers. comm.). Fieldwork conducted under contract to the Ministry of Forests and Range in 2008 will likely result in proposals for four more WHAs in the Rocky Mountain Forest District in the late winter of 2009.

2.0 DEVELOPMENT OF AN EFFECTIVENESS PROTOCOL FOR WILDLIFE HABITAT AREAS

The development of the badger WHA effectiveness monitoring protocol followed the general steps outlined in Erickson et al. (2005) and Paige and Darling (2009). The first steps included developing a conceptual model, framing the key monitoring questions, and selecting preliminary indicators (Hoodicoff 2006). Key threats to badgers relating to habitat loss or degradation, prey loss, and human-caused mortality were outlined in a conceptual model (Table 4). From this, monitoring questions were developed (Table 5), leading to a list of proposed indicators for monitoring and evaluating the effectiveness of badger WHAs (Table 6).

In 2006, a draft monitoring protocol addressing each indicator was developed and then updated in 2007 after pilot testing at three WHAs in the East Kootenays (Newhouse et al. 2007). Depending on the indicator, the protocol recommends that monitoring should take place every 2 years or every 6 years. The protocol also clarifies that badger WHA effectiveness is a combination of factors representing WHA functionality and the degree of risk to its integrity (Table 7; Appendix 1 provides more detail on methods). The functionality methods are most appropriate for the East Kootenays, or other areas where Columbian ground squirrels (*Spermophilus columbianus*) are the major prey. If this is not the case, then the methods do not provide procedures for directly considering prey abundance, although they do address range condition, which future research may more directly correlate to prey abundance indices. If another prey item is dominant and creates readily observed sign (such as marmot burrows or pocket gopher mounds), the methods used for considering ground squirrel burrow abundance could be readily adapted.

Newhouse et al. (2007) also illustrate how indicators relating to functionality are combined to establish an overall WHA functionality rating (Figure 1). The degree of risk presented by the relevant indicators is defined in three levels of severity.

1. *Immediate Risk* – Risk factors are identified that now impede 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 five years, but are likely to do so within 10 years if left unchecked.

***Table 4.* Conceptual model for evaluating badger WHAs (from Hoodicoff [2006]).**

Threats	Potential Effects on Badgers		Candidate Indicators	
	Habitat	Population	Habitat	Population
Habitat Loss and Degradation				
Urban development and intensive agriculture	• Decreases available grassland habitat • Decreases potential burrowing area • Increases fragmentation of habitat • Destruction of burrows	• Displacement of badgers • Increases disturbance from human activity	• Area of grassland habitat lost • Area of "diggable" soil lost • Index of fragmentation • Burrow density	• Frequency of burrow use • Number of badgers using WHA
Highway construction	• Increases road densities	• Increases potential for road mortality	• Road density	• Number of road mortalities
Highway maintenance	• Increases attractants to road rights-of-way	• Increases potential for road mortality	• Measure of vegetation on rights-of-way	• Number of road mortalities
Forest in-growth and encroachment	• Decreases suitable grassland habitat	• Displacement of badgers	• Change in percent canopy closure • Burrow density	• Frequency of burrow use • Number of badgers using WHA
Prey Loss				
Pest management	• Decreases prey abundance	• Increases energy required to find alternative prey resources	• Index of prey abundance	• Home range size
Poor range practices	• Decreases suitable habitat for prey • Decreases prey diversity	• Decreases in breeding opportunities and ovulation potential • Decreases in successful litters due to aborted implantation	• Index of prey abundance and diversity • Condition of grassland • Grazing intensity	• Presence of female or family • Number and size of successful litters
Human-caused Mortality				
Trapping and persecution		• Increases badger mortality		• Number of reported trapping mortalities
Traffic volumes and speed	• Decreases potential for safe crossing	• Increases badger mortality	• Road density (by road type)	• Number of road mortalities

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.

A matrix that combines functionality and risk results is used to determine the overall effectiveness rating for a badger WHA (Figure 2). Criteria for action are identified for each indicator.

The Ministry of Environment has developed a *Microsoft Excel* data entry spreadsheet for WHA evaluations (http://www.env.gov.bc.ca/wildlife/wsi/Template Wizard/lbs_transect.htm), which allows storage and retrieval of field data and photos recorded through the protocol.

Table 5. Indicators of effectiveness for badger WHAs and related monitoring questions (from Hoodicoff [2006]).

Indicators	Description	Monitoring Questions[a]	Spatial Scale	Intensity / Priority
Threat				
1. Area of suitable habitat lost	• Area of development / habitat conversion in and adjacent to WHA	1, 2	Local, Regional	Routine / High
2. Change in percent canopy closure	• Baseline measured and monitored over time; identify candidates for restoration	1, 2	Local	Routine / High
3. Road density by road type	• Length of primary (highway), paved, gravel roads in / adjacent to WHA (ha)	2, 5	Local, Regional	Routine / High
Habitat				
4. Burrow density	• Number of burrows per WHA, per ha	1, 3	Local	Extensive / High
5. Condition of grassland	• Survey of grassland condition and grazing intensity	1, 2	Local	Extensive / Moderate
Population				
6. Number of road mortalities	• Recorded within proximity of WHA	2, 5	Local, Regional	Routine / High
7. Frequency of burrow use	• Remote cameras • Hair snagging for species screening	1, 3	Local, Regional	Extensive / High
8. Number of badgers using WHA	• Mark / Recapture using hair snagging and DNA fingerprinting	1, 3	Local, Regional	Intensive / High
9. Presence of female or family	• Sightings, anecdotal • Remote cameras • Hair snagging for DNA fingerprinting	1, 4	Local	Extensive (Intensive) / High

a Monitoring questions used to determine whether a WHA provides key badger habitats:
1. Is the habitat (burrows, suitable soils, 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 safe for badgers?

Table 6. Proposed minimum indicators required (dots) and recommended (shaded) to evaluate badger WHA effectiveness (from Hoodicoff [2006]).

Indicators	WHA Effectiveness Evaluation Target[A]		
	WHA Effective / Not Effective	WHA Moderately Effective	WHA Highly Effective
Threat			
Area of suitable habitat lost	•	•	•
Change in percent canopy closure	•	•	•
Road density by road type	•	•	•
Habitat			
Burrow density	•	•	•
Condition of grassland			
Population			
Number of road mortalities			
Frequency of burrow use		•	•
Number of badgers using WHA			
Presence of female or family			•

a These targets are described in Hoodicoff (2006). The components of effectiveness (functionality and risk) are distinguished and effectiveness rankings are clarified in Newhouse et al. (2007).

Table 7. Indicators relating to the functionality of, or risk to, badger WHAs (grouped by level of effort required to monitor them), from Newhouse et al. 2007. More detail on the selection of these indicators is provided in Appendix 1.

Indicator	Level of Monitoring Effort	Indicator Type[a]
Area of suitable habitat alienated	Low (routine)	Risk
Change in percent canopy closure	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[b]	Moderate (extensive)	Functionality
Badger activity disproportionately near a highway	Moderate (extensive)	Risk
Number of badgers using WHA	High (intensive)	Functionality
Presence of a female or family group[c]	High (intensive)	Functionality
Frequency of burrow use	High (intensive)	Functionality

a Functionality = evidence of WHA supporting current activity by badgers and their prey; risk = probability that use of WHA by badgers will decline over time, or that use of WHA by badgers leads to high badger mortality rate.

b Where ground squirrels are a major food source.

c Distinct from moderate-effort (extensive) monitoring for family groups through visual sightings.

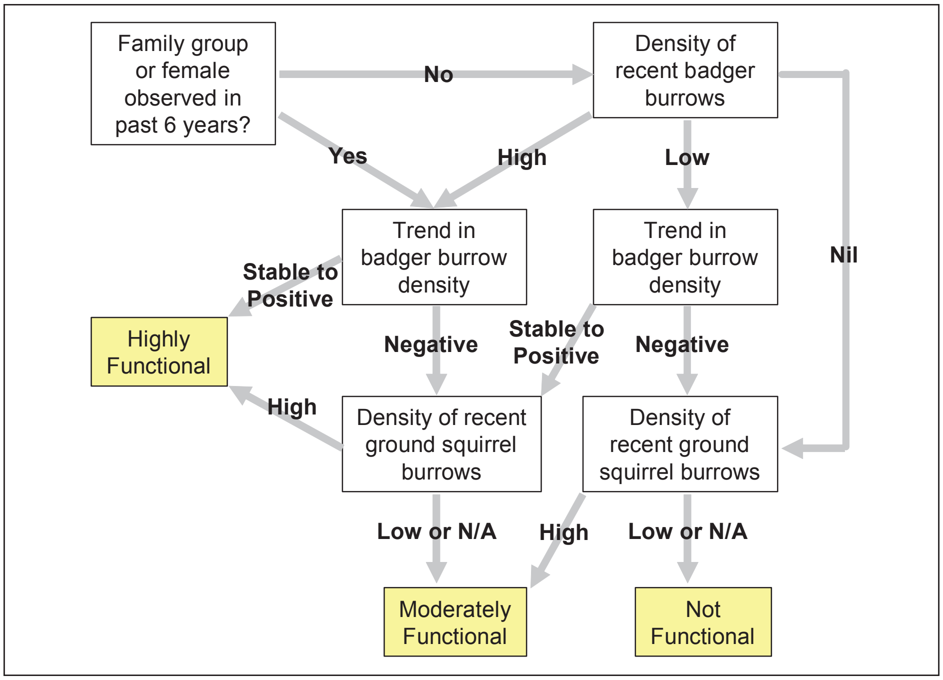

Figure 1. ***Assessment process for assigning badger WHA functionality ratings (from Newhouse et al. [2007]). According to Newhouse et al. (2007:6): "Densities of recent (occupied during year of survey) badger or ground squirrel burrows considered to be 'high' are to be determined regionally based on 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'."***

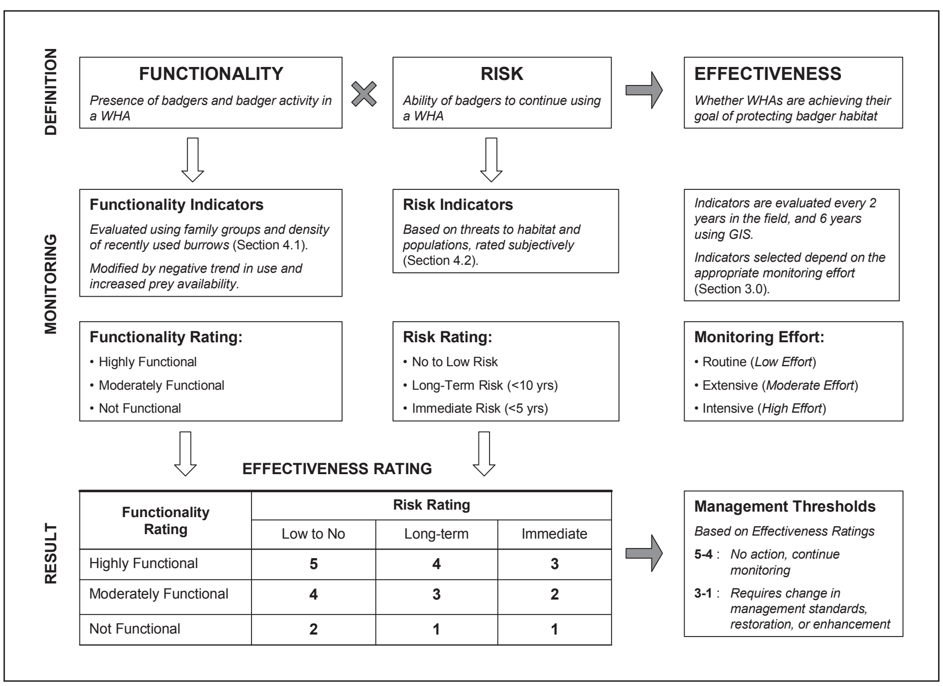

Figure 2. ***Badger WHA effectiveness evaluation summary (from Newhouse et al. [2007]). Numerical ratings based on a 1-5 ordinal scale, with 5 being most effective and 1 being least effective.***

3.0 APPLICATION OF EFFECTIVENESS MONITORING METHODS

3.1 *Study Design and Related Field Sampling Protocol*

The methods outlined in the effectiveness evaluation protocol (Newhouse et al. 2007) were developed specifically for the purpose of WHA monitoring. Although these methods include some data collected through other standardized approaches (such as traffic volumes or the Vegetation Resource Inventory), they are not directly drawn from other provincial standards such as those developed for the Resources Inventory Standards Committee. However, the range status scoring summarized in the protocol follows a method developed for Alberta (Adams et al. 2005). If WHAs are designated in the Nicola Valley, assessments will follow the local scoring structure developed by Wikeem and Wikeem (2005), which incorporates a standardized plot layout.[2] One additional range assessment measure, the percent canopy cover by species of trees and shrubs, follows a standard provincial method (Ministry of Environment, Lands and Parks and Ministry of Forests 1998).

The ability to statistically compare results within a WHA across years, or between WHAs within years, varies by indicator.

1. In some cases, a statistical analysis is unnecessary, as the data represent a 100% sample. For example, the area of permanent habitat loss, change in percent canopy closure, and road density are all based on GIS mapping for the WHA and surrounding landscape. Setting aside possible error or obsolescence in the mapping, values obtained represent "reality" and not a sample of it. In such cases, the results directly reflect the situation and no statistical comparison between years or WHAs is required. The same is true for the traffic volume indicator, assuming data are available for the full year.
2. Other indicators are not amenable to statistical analyses for several reasons. These indicators include the rapid on-site assessment (simply a quick, subjective overview of WHA status), the presence of family groups as indicated by sightings from the public or opportunistic telemetry data (for which sampling effort is essentially impossible to define), and the number of road mortalities (also with an undefined sampling effort).
3. Some indicators are well suited to statistical analyses. These include badger and ground squirrel burrow densities, and the proportion of badger burrows adjacent to highways. These indicators are estimated by sampling a small portion of the WHA. In the case of burrow densities, belt transects for badgers cover 10% or 5% of the WHA, depending on whether the WHA is less than or greater than 100 ha, respectively. The comparable values for ground squirrel transects are 4% and 2% of the WHA.[3] Burrow data are summarized in contiguous, 50-m segments of each transect and therefore some lack of independence between adjoining segments is likely. Methods to subsample the segments (to achieve independence) or to otherwise consider autocorrelation have not yet been developed. The protocol suggests that dramatic negative trends should be apparent (e.g., 30% declines in burrow density on an annualized basis) before assuming actual declines. In the absence of formal statistical testing, this recognizes the variability inherent in measuring the activity of a wide-ranging carnivore within relatively small WHAs. More precisely testing for significant differences within and between WHAs should now be feasible, given the amount of data collected.
4. Although range assessment data can be subjected to statistical analyses, sampling issues may exist. Range data are collected at one plot per mapped forest cover polygon (Newhouse et al. 2007). This approach allows the development of range-condition maps upon which to plot burrow survey results, and assumes that range conditions for each plot are extrapolated within a GIS environment to the entire forest cover polygon. Such a methodology favours visual within-WHA evaluations of burrow density against range condition; that is, its goal is to infer how range condition might influence

2 The Grasslands Conservation Council will release a new scoring structure in early 2009 that will provide scoring systems for each of five plant communities rather than by region (B. Delesalle, Grasslands Conservation Council, pers. comm.).

3 For WHAs up to 100 ha, parallel transects are established at 100-m intervals, while for WHAs >100 ha, the spacing is 200 m. Badger burrows are counted within a strip extending 5 m on either side of the transect centerline (10 m total width) and ground squirrel burrows are counted on a strip 2 m on each side of the centerline (4 m total width). This protocol is based on Newhouse et al. (2007) except that the 200-m spacing for larger WHAs was a later modification (Kinley and Page 2008).

burrow density within individual WHAs. An alternative approach would randomly sample range condition across the WHA, independent of forest cover mapping, which would facilitate the overall comparison of range condition to burrow densities between WHAs, but would not be amenable to complete mapping. Thus, range sampling layout is designed primarily to answer within-WHA rather than between-WHA questions. Even so, the ability to compare range condition between forest cover map polygons within a WHA is limited because only one plot (transect) is assessed per polygon. This is primarily a function of cost. Range plots are established by forest cover polygon. This means they are not randomly distributed, and so cumulatively will not necessarily represent the overall range condition in the WHA. For example, one forest cover polygon might cover 70% of a WHA, with six more polygons covering only 5% each, yet each polygon would still have one plot. This limits the ability to use data collected under the current sampling design *post hoc* to compare range condition between WHAs.

5. Protocols for indicators that require "intensive" monitoring effort (e.g., indicators that require telemetry, DNA hair snagging, or motion-sensor cameras) should be developed on a case-specific basis (Newhouse et al. 2007). If such activities are undertaken, they essentially represent stand-alone research projects and require the development of individualized statistical methods.

3.2 *Pilot Projects and Baseline Monitoring*

In 2006 and 2007, the monitoring protocol was tested and baselines were established for all seven approved WHAs in the Rocky Mountain Forest District (Table 2), and one proposed WHA in each of the Rocky Mountain and Kootenay Lake forest districts (Table 3; Page et al. 2007, Kinley and Page 2008). These nine WHAs cover 854 ha. In 2006, preliminary pilots for the first three WHAs led to minor changes in the monitoring protocol. Before the 2007 field season, one additional change reported in Kinley and Page (2008), but not yet identified in a protocol document, concerned burrow transect spacing at 200 m rather than 100 m for WHAs greater than 100 ha. Baseline effectiveness evaluations have now been conducted for nine proposed or approved WHAs.

3.3 *Results of Baseline Monitoring*

The evaluations done to date (Page et al. 2007; Kinley and Page 2008) were the first for each of the WHAs investigated, and thus provided baselines rather than trend data. This limits the ability to draw conclusions from most of the risk or functionality indicators (i.e., for area of permanent habitat loss, change in percent canopy closure, road density, and trends in number of badger and ground squirrel burrows). To make some use of the data on current conditions, evaluations considered those factors in an absolute or spatial sense, rather than in temporal terms, including:

- subjectively considering the percentage of permanent habitat loss;
- comparing crown closure within each WHA to that present in the surrounding 1-km and 3-km radius circles; and
- comparing road density within each WHA to that present in the surrounding 1-km and 3-km radius circles.

It is unclear how range-condition measures can be directly correlated to prey abundance, whether from a trend or absolute perspective. As no gross relations were evident in the distribution of ground squirrel or badger burrows relative to range condition, this indicator did not influence WHA effectiveness ratings. As a result of these factors, evaluations of WHA effectiveness are preliminary.

In evaluating the first three WHAs (Page et al. 2007), threshold values (corrected to expected end-of-season numbers) were proposed to distinguish "low" from "high" burrow densities for both ground squirrels and badgers. These thresholds were partially based on previous research using radiotelemetry and habitat evaluations. The threshold for recent ground squirrel burrows (75 per hectare) was established as the arithmetic mean of the density around burrows of radio-tagged badgers (considered to represent the highest stratum) and at random plots in the Interior Douglas-fir biogeoclimatic zone. The threshold for recent badger burrows (6 per hectare) was the geometric mean of these two values and reflects the clumpy distribution of badger burrows in relation to sample plots which started at burrows. These thresholds were also applied when evaluating the next six proposed or approved WHAs (Kinley and Page 2008). By using them and other measures of risk and functionality, effectiveness was rated (summarized in Table 8; details in Appendix 2). As noted previously, establishing trends in burrow densities is

Table 8. Effectiveness of badger WHAs investigated in 2006 and 2007 (Page et al. 2007; Kinley and Page 2008). Effectiveness ratings are on a 5-point scale.

Number	Name	Functionality	Risk	Effectiveness[a]
4-088	Tata Creek Airport North	Moderate	Low to nil	4
4-089	Lost Dog South	Moderate	Low to nil	4
4-090	Tata Creek Airport South	High	Long-term	4
4-091	McGinty Lake	High	Low to nil	5
4-092	North Kikomun Creek	Moderate	Low to nil	4
4-102	Fir Mountain	High	Low to nil	5
4-103	Johnson Lake	High	Low to nil	4
N/A	Sheep Creek	Moderate	Low to nil	4
N/A	West Yahk River	High	Low to nil	5

a Effectiveness rating lower than 4 indicates need for change in management standards, restoration, or enhancement (Figure 2).

not yet possible, so functionality ratings bypassed this consideration. To date, no control (non-WHA) sites have been established and no statistical analyses have been conducted using evaluation results; reports have used numerical summaries and mapping.

The cost of evaluating WHA effectiveness depends largely on WHA size, access, and the day rates of contractors. The 50% reduction in burrow-density sampling intensity for WHAs greater than 100 ha also has an important bearing on cost; smaller WHAs are more expensive per hectare to evaluate. In 2007/2008, six WHAs ranging in size from 4 ha to 236 ha were evaluated (total of 560 ha, with three WHAs > 100 ha). The total cost for the six WHAs was just over $24,000, and included planning, mapping, layout, fieldwork, data entry, analysis, write-up, and correspondence.

4.0 RECOMMENDATIONS FOR FUTURE EFFECTIVENESS EVALUATIONS

4.1 *Continued Monitoring*

Most of the indicators of effectiveness for badger WHAs relate to temporal trends. As such, repeated monitoring (every two or six years, depending on the indicator) is part of the protocol. Although the timing between repetitions is not critical, trends cannot be established unless repeated monitoring occurs. The 38 existing or proposed WHAs may increase to almost 50 shortly, with only nine having been evaluated once, and none evaluated more than once. Considerable monitoring effort will be required over the next few years to determine a baseline and trends for each WHA. Therefore, monitoring all WHAs may not be possible, requiring the selection of a subset. If this occurs, a statistician should be consulted to develop an appropriate sampling regime.

4.2 *Range Condition Monitoring*

The most important information gap is how range condition is likely to affect badgers. It is generally assumed that Columbian ground squirrels are unlikely to be negatively affected by poor range condition (and may benefit from significant grazing). If this is the case, then investigating range condition where ground squirrels are the primary prey item will potentially carry little benefit.[4] In contrast, overall mice and vole diversity and abundance are assumed to be negatively affected by heavy grazing, although these assumptions have not been confirmed or quantified in relation to WHAs. The effects of range condition on other prey species such as yellow-bellied marmots (*Marmota flaviventris*)

4 If a decision is made to test this assumption, then continued range monitoring would be appropriate, but more rigorous methods would likely be needed to allow hypothesis testing.

have also not been quantified. Therefore, even where ground squirrels are not the predominant prey, prey abundance is very difficult to predict based on observed range condition. Furthermore, range-condition data for large WHAs is quite time-consuming to collect, enter, analyze, and map. This indicator consumes 20–25% of the effectiveness-evaluation budget, despite the inability to correlate WHA effectiveness with range condition. To date, collection of range data has taken place, but it has not been applied to WHA effectiveness evaluations.

Consequently, the determination of general range condition is currently of little benefit. Instead, attention should be given to:

1. the regional identification of primary prey items that may exert a limiting effect on badger populations; and
2. the determination of more direct abundance indices for these prey species, either by monitoring animal sign or by finding specific indicators of habitat quality for them.

For example, ground squirrel burrow monitoring techniques could be applied to marmot burrows, pocket gopher mounds, or muskrat pushups. Likewise, in some ecosystems a correlation may exist between certain species of voles or mice and specific habitat elements, such as coarse woody debris, particular plant species, or plant architecture. Although this approach would result in variable monitoring methods by region or ecosystem, it would reduce the time spent on general indicators that are of little known utility. Refining the conceptual model to reflect limiting factors by region may be worthwhile. In summary, overall range condition or plant species composition probably does not directly affect badgers, yet significant funding has gone into range monitoring. Current approaches should therefore be critically evaluated. Focussing on either the abundance or the specific habitat requirements of prey species that do directly influence badger populations would be far more productive.

Nevertheless, more careful analysis may reveal that badgers in some areas use several types of prey in roughly equal proportions and that the abundance of these species is directly linked to general measures of range condition. If such situations occur, determining likely trends of dominant prey species through generalized range-condition monitoring may actually be more efficient than direct estimation of prey density. One clear benefit of current range monitoring methods is that overstorey and shrub cover are evaluated. Trends in these vegetation layers could provide an early indication of shifts in the generally open habitat used by badgers throughout their range. Even if other range indicators are dropped, maintaining this aspect of range monitoring should be considered.

If range monitoring does continue, the scoring system for grassland health available in early 2009 (B. Delesalle, Grasslands Conservation Council, pers. comm.) should replace the existing system referenced in the protocol (Newhouse et al. 2007).

4.3 *Burrow Density*

The points separating "high density" from "low density" of badger or ground squirrel burrows should be periodically re-evaluated. Only two of the nine WHAs evaluated were considered to have a high density of recent badger burrows, and only four of the nine had a high density of recent ground squirrel burrows (Appendix 2). Identified thresholds were established under the protocol following a rationale, but with limited data or review. None of the available data relates burrow densities to particular animal densities, or even any target animal densities if such correlations were available. Until trends within individual WHAs are known, the distinction between a high versus low density of burrows can affect the functionality rating (Figure 1), which in turn affects the effectiveness rating. Data from badger research projects across the province as well as target population densities for badgers and prey should be considered in refining either provincial or regional benchmarks for "high density" of burrows.

Because the number of recent badger and ground squirrel burrows increases continuously through the year, a method was developed to standardize results in relation to the survey date (Appendix 2 in Newhouse et al. 2007). Although this method's assumptions have not been tested, running identical transects repeatedly in a test area would be a relatively straightforward method of doing so. This would facilitate more accurate comparisons between WHAs or years because having consistent sampling dates for all WHAs in all years would be virtually impossible.

4.4 *Statistical Analyses*

The protocol does not include statistical methods. Most of the indicators do not require statistical comparisons (i.e., they are 100% samples, such as summing of all number of kilometres of road in the WHA, so apparent trends are true trends). Many are not amenable to statistical analysis because they represent opportunistic observations with undefinable sampling effort (such as sightings made by the public), or require statistical design specific to more detailed research efforts (e.g., all of the "intensive" indicators). Some indicators (e.g., range) need a reconsideration of their utility. However, the most direct indicators of WHA functionality—the density of badger and prey burrows—are well suited to statistical analysis.

A statistical methodology should be developed to assess burrow density and its related indicator, the proportion of badger burrows falling within 200 m of a highway. In principle, the number of burrows in each of four classes (badger or ground squirrel; recent or total) can be compared between WHAs, or within a WHA between years, by considering each 50-m segment of transect as a sampling unit. This requires use of a t-test or, if the number of burrows per segment is non-normally distributed a Wilcoxon test. The same is true for comparing all segments within 200 m of the highway to all other segments. However, it is not clear whether samples representing adjoining segments are truly independent. If the samples lack independence, then performing statistical tests would be inappropriate until the requirement for independence is met, presumably by drawing on a subsample of the segments for which data were recorded. This situation is common to any data collected in segments along transects. A statistician should be consulted to determine whether adjacent segments (or even adjacent transects) are independent of each other, or at what separation independence is achieved.

If the range status indicator (or some derivative of it) continues to be used, then a statistical approach for layout and testing should also be developed. First, it should be decided whether to allocate funds primarily to comparisons within WHAs (i.e., using forest cover polygons), to comparisons between WHAs, or to comparisons between WHAs and control sites. If the goal is to compare between WHAs, or between WHAs and controls, then it will likely be necessary to switch from plots established on a one-per-polygon basis to randomly distributed plots, or to weight the results obtained for individual polygons of varying sizes to determine an overall value for each WHA. If the focus is on within-WHA comparisons, some certainty is required that plots represent the forest cover polygon under consideration. This might result in multiple plots per polygon and, therefore, a considerably greater cost for monitoring. Some WHAs include over 10 polygons and roughly 20–25% of evaluation budgets already goes to range sampling even with just one plot per polygon.

4.5 *Controls*

The overall value of WHAs may be evaluated in part through a comparison to control areas with similar biophysical characteristics and with no GWMs. This comparison would help determine whether changes evident in the WHA resulted from region-wide or province-wide changes in badger abundance (which would not be clear from evaluating only WHAs) or were related to the implementation of GWMs in the WHA, and would therefore place WHA assessments in a broader context. However, this approach has at least two potential drawbacks. First, the total cost of monitoring per WHA would increase; if the protocol is followed, annual monitoring of 10–20 WHAs will likely be required, making funding problematic. Second, the only statistically suitable control areas may already be identified as WHAs, making comparability (and the absence of unknown, but confounding factors) between controls and WHAs difficult to achieve. If the primary focus of WHA monitoring is to compare a representative sample of WHAs to control sites, then a statistician should be consulted to establish a sampling strategy that will provide confidence in the comparability of controls to WHAs and still allow for the regular monitoring of sufficient WHAs to assess the effectiveness of individual WHAs.

4.6 *Costs*

Burrow transects are conducted more rapidly with a two-person crew (as per the protocol) than by a single person. This approach allows one person to navigate and record data while the other person makes the primary observations. However, this does not mean that the work is done twice as fast with two people. Transects completed by a two-person crew require roughly 50% more person-days. The same is probably true for range assessments. Running transects with one person rather than two would likely save about 20% of the total evaluation budget. If two individuals work on adjacent transects, with radio- or mobile-phone contact, savings could be achieved without significantly compromising safety. This would combine the speed of a one-person crew with the safety of a two-person crew. Additional savings might be realized if most or all of the generalized range assessments were replaced with specific tests for key prey species.

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APPENDICES

APPENDIX 1. Protocol Methods for Badger WHAs

Current protocols for monitoring badger WHA effectiveness are described in Newhouse et al. (2007). One change not captured in the protocol document relates to the spacing between transects used to monitor burrow density. Following a discussion with W. Erickson (Ministry of Forests and Range, Victoria) and a re-examination of 2006 field data during the spring of 2007, it was determined that increasing the inter-transect spacing from 100 m to 200 m for WHAs with an area greater than 100 ha would likely result in little loss of precision and considerable cost savings (Kinley and Page 2008).

Table A1 provides a summary of the rationale and methods. Note that most of these measures are based on trends rather than absolute values. For example, a WHA with 40% crown closure might be as (or more) valuable to badgers than a WHA with 10% closure depending on many other factors. However, if crown closure changes from 10% to 40% over several decades, then the WHA is likely declining in suitability.

Table A1. Summary of badger WHA evaluation methods (from Newhouse et al. [2007]). Not all indicators might be used, depending on goals and budget.

Indicator	Rationale	Analysis Type	Method
Area of suitable habitat alienated	Measures permanent loss of habitat	GIS-based[a]	Use Grasslands Conservation Council mapping to determine amount of historic grassland or open forest lost to intensive agriculture, or urban or industrial development.
Change in percent canopy	Better badger habitat normally associated with lower canopy closure	GIS-based[a]	Use VRI to summarize area in each crown closure class (10% increments).
Road density by road type	Indexes potential risk of roadkill, the main mortality source	GIS-based[a]	Use TRIM mapping to summarize length of road in each of three classes (trail, gravel, paved).
Traffic volume on adjacent roads	Indexes potential risk of roadkill	Existing database	Report MOTI traffic volume data if a highway is adjacent to WHA.
Number of road mortalities	Identifies minimum number of roadkills	Existing databases (mainly)	Examine regional badger sightings database and MOTI's WARS database for roadkill records within 3 km of WHA centroid; interview tenure holders and ministry staff.
Rapid on-site assessment	General overview of WHA conditions	Site visit	Look for obvious issues relating to risk or functionality, to supplement or replace full fieldwork.
Badger burrow density (and trends over time)	Direct index of badger activity in WHA	Fieldwork	Establish transects at 100-m intervals (200 m if WHA > 100 ha); record badger burrows within 5-m strip on each side of transect and classify as recent (year of study) or older; summarize in 50-m segments and convert to density (number per hectare) for segments and entire WHA; correct to expected annual total based on date of survey
Range status	Likely correlates to abundance of some prey, such as voles[b]	Fieldwork	Evaluate trends in range status based on species composition, community structure, litter estimates, site stability, weed presence and change in shrub and overstorey layers. Establish permanent plots in each forest cover polygon within WHA, then collect data and take photos for each plot.

continued...

Table A1. Concluded

Indicator	Rationale	Analysis Type	Method
Presence of a family group	Suggests WHA supports reproduction	Existing databases (mainly)	Examine regional badger sightings database for records of > 1 badger per sighting in WHA; interview tenure holders and ministry staff.
Ground squirrel burrow density[c]	Index of abundance of main prey item, where applicable	Fieldwork	Same as for badger burrow density, but transects extend only 2 m on each side of transect centreline, and burrow age classified by 50-m transect not each burrow.
Badger activity disproportionately near highway	Indexes potential risk of roadkill	Assessment of field data	Use badger burrow fieldwork data to determine whether badger activity is disproportionately within 200 m of highways.
Number of badgers using WHA	Indicates minimum number of badgers using WHA	Intensive fieldwork	Use hair-snagging techniques to collect DNA samples to determine number of unique genotypes. Likely only done in conjunction with ongoing research.
Presence of a female or family group[d]	Indicates WHA supports reproduction	Intensive fieldwork	Use hair-snagging techniques as above and employ remote cameras; DNA analysis indicates presence of females and number of individuals using single burrows; cameras also indicate minimum number of individuals.
Frequency of burrow use	Indicates degree of burrow use	Intensive fieldwork	Use hair-snagging techniques and remote cameras as above to indicate whether burrows are used.

a Within WHA and within circles of 1 km and 3 km radius centred on the WHA centroid.

b Done for all WHAs, but most instructive where ground squirrels are not the dominant food source (ground squirrels believed to show little sensitivity to poor range condition).

c Only if ground squirrels are a dominant food source; can be adapted to other burrowing species such as northern pocket gophers or yellow-bellied marmots if predominant in diet.

d This is the “intensive” rather than “extensive” method for determining presence.

APPENDIX 2. Detailed Summary of Evaluations Conducted to Date for Badger WHAs

Table A2. Badger WHA evaluation results presented in Page et al. (2007) and Kinley and Page (2008). The first four risk measures relate to habitat; the last four relate to mortality risk.

Measure	Rating / Indication								
	Fir Mountain	Johnson Lake	Ta Ta Creek Airport South	Lost Dog South	North Kikomun Creek	Sheep Creek	McGinty Lake	Ta Ta Creek Airport North	West Yahk River
Functionality									
Females, family groups or maternal dens	Yes	No	Yes	No	No	No	Yes	No	No
Density of recent badger burrows	Low	High	High	Low	Low	Low	Low	Low	Low
Density of recent ground squirrel burrows	High	High	High	Low	Low	Low	Low	Low	High
Overall	H	H	H	M	M	M	H	M	H
Risk (degree of risk indicated)									
Rapid on-site assessment	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Range condition[a]	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown	unknown
Area of permanent habitat loss[b]	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil	unknown
Change in canopy closure[c]	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil
Road mortalities	low-nil	low-nil	low-nil	long-term	long-term	low-nil	low-nil	low-nil	low-nil
Adjacency of burrows to highways	low-nil	long-term	immediate	low-nil	low-nil	low-nil	low-nil	long-term	low-nil
Traffic volume on adjacent highways	low-nil	long-term?	unknown	long-term?	low-nil?	low-nil	low-nil	long-term?	low-nil
Road density	low-nil[d]	long-term[e]	long-term[f]	low-nild	low-nil[f]	long-term[e]	low-nil[f]	low-nil[f]	low-nil[f]
Overall	low-nil	long-term	long-term	low-nil	low-nil	low-nil	low-nil	low-nil	low-nil
Effectiveness (1 = worst, 5 = best)	5	4	4	4	4	4	5	4	5

a Relationship between range condition and risk unknown.

b Recent trend not known (1st year); historic data show little or no loss of grassland (no data for West Yahk River).

c Recent trend not known (1st year); crown closure in WHAs similar to or less than surrounding 1-km and 3-km-radius circles; effect of moderate canopy closure on badger habitat unclear.

d Based on low density in WHA and moderate density in surrounding landscape.

e Based on high density in WHA but lower density in surrounding landscape.

f Based on moderate density in WHA and surrounding landscape.