Recovery Strategy for the Badger (*Taxidea taxus*) in British Columbia

Prepared by the *jeffersonii* Badger Recovery Team

BRITISH COLUMBIA
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Ministry of Environment

September 2008

About the British Columbia Recovery Strategy Series

This series presents the recovery strategies that are prepared as advice to the Province of British Columbia on the general strategic approach required to recover species at risk. The Province prepares recovery strategies to meet its commitments to recover species at risk under the *Accord for the Protection of Species at Risk in Canada*, and the *Canada – British Columbia Agreement on Species at Risk*.

What is recovery?

Species at risk recovery is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

A recovery strategy represents the best available scientific knowledge on what is required to achieve recovery of a species or ecosystem. A recovery strategy outlines what is and what is not known about a species or ecosystem; it also identifies threats to the species or ecosystem, and what should be done to mitigate those threats. Recovery strategies set recovery goals and objectives, and recommend approaches to recover the species or ecosystem.

Recovery strategies are usually prepared by a recovery team with members from agencies responsible for the management of the species or ecosystem, experts from other agencies, universities, conservation groups, aboriginal groups, and stakeholder groups as appropriate.

What's next?

In most cases, one or more action plan(s) will be developed to define and guide implementation of the recovery strategy. Action plans include more detailed information about what needs to be done to meet the objectives of the recovery strategy. However, the recovery strategy provides valuable information on threats to the species and their recovery needs that may be used by individuals, communities, land users, and conservationists interested in species at risk recovery.

For more information

To learn more about species at risk recovery in British Columbia, please visit the Ministry of Environment Recovery Planning webpage at:

<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

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Recommended citation

Jeffersonii Badger Recovery Team. 2008. Recovery Strategy for the Badger (*Taxidea taxus*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, B.C. 45 pp.

Cover illustration

Andrea Toth

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

Publication information

ISBN 978-0-7726-6072-5

Cataloguing in Publication: Pending

Disclaimer

This recovery strategy has been prepared by the *jeffersonii* Badger Recovery Team, as advice to the responsible jurisdictions and organizations that may be involved in recovering the species. The British Columbia Ministry of Environment has received this advice as part of fulfilling its commitments under the *Accord for the Protection of Species at Risk in Canada*, and the *Canada — British Columbia Agreement on Species at Risk*.

This document identifies the recovery strategies that are deemed necessary, based on the best available scientific and traditional information, to recover Badger populations in British Columbia. Recovery actions to achieve the goals and objectives identified herein are subject to the priorities and budgetary constraints of participatory agencies and organizations. These goals, objectives, and recovery approaches may be modified in the future to accommodate new objectives and findings.

The responsible jurisdictions and all members of the recovery team have had an opportunity to review this document. However, this document does not necessarily represent the official positions of the agencies or the personal views of all individuals on the recovery team.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this strategy. The Ministry of Environment encourages all British Columbians to participate in the recovery of Badgers.

RECOVERY TEAM MEMBERS

Eric Lofroth, co-chair, B.C. Ministry of Environment, Victoria, BC
Roger Packham, co-chair, B.C. Ministry of Environment, 100 Mile House, BC
Ted Antifeau, B.C. Ministry of Environment, Nelson, BC
Diane Casimir, Parks Canada Agency, Calgary, AB
Alan Dibb, Parks Canada Agency, Radium Hot Springs, BC
Orville Dyer, B.C. Ministry of Environment, Penticton, BC
Wayne Erickson (ret.), B.C. Ministry of Forests and Range, Victoria, BC
Mary Ellen Grant, Natural Considerations Consultants, Kamloops, BC
Corinna Hoodicoff, Summit Environmental Consultants Ltd., Vernon, BC
Larry Ingham, Columbia Basin Fish & Wildlife Compensation Program, Invermere, BC
Agnes Jackson, B.C. Cattlemen's Association, Kamloops, BC
Karl Larsen, Thompson Rivers University, Kamloops, BC
Nancy Newhouse, Sylvan Consulting, Invermere, BC
Brent Persello, B.C. Ministry of Transportation and Infrastructure, Kamloops, BC
Julie Steciw, B.C. Ministry of Environment, Williams Lake, BC
John Surgenor, B.C. Ministry of Environment, Kamloops, BC
Karyn Sutherland, FORREX, Kamloops , BC
Rich Weir, Artemis Wildlife Consultants, Armstrong, BC

AUTHORS

Ian T. Adams, Corvus Communications, Cranbrook, BC
Richard Weir, Artemis Wildlife Consultants, Armstrong, BC
Eric Lofroth, B.C. Ministry of Environment, Victoria, BC
Roger Packham, B.C. Ministry of Environment, 100 Mile House, BC

RESPONSIBLE JURISDICTIONS

The British Columbia Ministry of Environment is responsible for producing a recovery strategy for the Badger under the *Accord for the Protection of Species at Risk in Canada*. The B.C. Ministry of Forests and Range, B.C. Ministry of Transportation and Infrastructure, Parks Canada Agency, and Environment Canada's Canadian Wildlife Service participated in the preparation of this recovery strategy.

ACKNOWLEDGEMENTS

The *jeffersonii* Badger Recovery Team was formed in the winter of 2001. The team built on the substantial advances in knowledge of Badger ecology and need for conservation initiated by Nancy Newhouse and Trevor Kinley (Sylvan Consulting, Invermere, B.C.); Richard Weir and Helen Davis (Artemis Wildlife Consultants, Armstrong, B.C.); Corinna Hoodicoff (Summit Environmental Consulting Ltd., Vernon, B.C.), Karl Larsen (Thompson Rivers University, Kamloops, B.C.), Roger Packham (Ministry of Environment, 100 Mile House, B.C., and John Surgenor (B.C. Ministry of Environment, Kamloops, B.C.).

Assistance from the Ecosystems Branch of the B.C. Ministry of Environment (Victoria) was critical to preparing this draft. Especially helpful have been Mike Badry, Kari Nelson, and Dave Fraser.

Reviews by (alphabetically) Jeff Brown, Diane Casimir, Don Eastman, Jenny Feick, Dave Fraser, Cindy Haddow, John Messick, Marie-José Ribeyron, Mary Rothfels, Dave Toews, and Sarah Young on earlier drafts of this strategy were extremely constructive.

The recovery strategy was funded by Parks Canada's Species at Risk Fund and B.C. Ministry of Environment. Thanks to Alan Dibb (Kootenay National Park, Radium Hot Springs, B.C.), David Poll (retired, Parks Canada Agency, Calgary, AB), and Leah de Forest (Parks Canada Agency, Hull, QC) for making this possible. World Wildlife Fund Canada funded the recovery team to meet and discuss an earlier draft of this strategy; the recovery team appreciates their assistance and support of Badger research and conservation.

Thanks to all members of the recovery team for their time and efforts at conserving Badgers in British Columbia. Finally, much appreciation is due to the innumerable landowners who are committed to ensuring Badgers have a future in British Columbia.

EXECUTIVE SUMMARY

British Columbia represents the north-western limit of Badger (*Taxidea taxus*) range. In Canada, the subspecies *T. taxus jeffersonii* occurs only in B.C. (all Badgers in B.C. are *T. taxus jeffersonii*) where they range throughout the dry Southern Interior of B.C. NatureServe's global rank for the entire Badger species is G5 (secure). In B.C., Badgers are ranked S1 (critically imperilled) and Red-listed by the B.C. Conservation Data Centre and the *jeffersonii* sub-species is designated as "endangered" by Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The current population estimate of Badgers in B.C. is 230–340 individuals. Although historical population data are not available, this number is widely accepted as a long-term decline from likely historical populations based on known pelt returns between 1919 and 1977. The B.C. Badger population is also thought to have declined over the past two decades based on low number of juvenile captures, low number of female captures in certain regions, and anecdotal reports from landowners citing Badgers, in most areas, becoming less common over the past 20 years.

Recent genetic analyses suggest that Badgers in B.C. form at least two distinct populations (Thompson-Okanagan and East Kootenay) that may have independent population dynamics. Relatively low levels of genetic variability and genetic exchange with populations beyond the Thompson-Okanagan suggest this population is at considerable conservation risk because of its isolation and susceptibility to negative stochastic events.

Badgers have two main habitat requirements: diggable soil and prey. In B.C., Badgers may be found from hot, dry grassland valley bottom to alpine tundra environments, with preference for grassland/fields and open-canopied forests. The three biogeoclimatic zones most preferred by Badgers (Bunchgrass, Ponderosa Pine, and Interior Douglas-fir) are among the most poorly represented by protected areas in B.C. and under the most intense development pressure.

Badger diet is varied. Where they occur, Columbian Ground Squirrels (*Spermophilus columbianus*) and Yellow-bellied Marmots (*Marmota flaviventris*) are preferred prey. Where Columbian Ground Squirrels and marmots are absent, Badgers rely on alternate prey species (e.g., microtine rodents) that require grassland communities with considerable grass structure and carryover.

The Badger is the only fossorial (adapted to digging) carnivore in the grassland and open forest ecosystems of the southern B.C. Interior. Burrows dug by Badgers form important habitat components for other species, and their digging and associated mounds are important features of grassland and open forest ecosystems.

There are numerous proximate threats to Badger populations and habitats including: road mortality, urban development, cultivation, viticulture and orchards, poor range management, forest in-growth and encroachment, reservoir flooding, non-targeted trapping, persecution, loss of prey, and secondary poisoning via prey.

Badgers have little direct economic value in B.C. because they are protected from commercial trapping and demand for Badger fur from other jurisdictions is low. Several industries benefit from Badgers:

- Badgers help control burrowing rodents that cause considerable damage to livestock and farm machinery.
- Golf course operators benefit from natural control of ground squirrels and Yellow-bellied Marmots on their courses.
- Forest companies may benefit from relaxed free-to-grow standards for specific cutblocks for Badger habitat.

Socio-economic costs can be expected for some aspects of Badger recovery including:

- Current rates of ongoing urban development in key areas (e.g., Okanagan, Kamloops, and East Kootenay) are likely incompatible with viable local Badger populations.
- Road maintenance and construction must include safe crossing structures (e.g., permeable concrete roadside barriers, culverts) in areas of high Badger activity.

Key biological factors that may affect recovery include:

- low reproductive capacity;
- stochastic threats to small populations;
- low juvenile survivorship;
- large home range size, which may impact survival and reproductive success;
- reduced genetic variability in isolated populations at the species' range limit; and
- behavioural traits that make Badgers more susceptible to mortality, particularly due to road kill.

Substantial research and recovery actions have been undertaken for Badgers in B.C. Research projects in the East Kootenay, Thompson-Okanagan, and Cariboo regions have greatly increased our knowledge of Badger ecology, habitat requirements, and conservation. However, many knowledge gaps remain and have been identified.

Recovery of Badgers in B.C. is ecologically and technically feasible provided that road mortality and habitat loss are reduced, individuals are adequately protected from extermination killing, and populations are augmented or reintroduced when required. Anticipated challenges include mitigating high road mortality, maintaining large tracts of well-connected high quality habitat, and eliminating needless killing of Badgers.

The long term goal is to achieve and ensure a viable population of Badgers throughout their historic range in B.C. The 5-year goal is to increase the total Badger population in B.C. to a minimum of 400 adults.

Five objectives are identified to achieve both the long term and 5 year goals. Performance targets are identified for each objective.

1. ensure suitable habitat for Badgers and their prey
2. increase Badger survivorship and recruitment
3. maintain or increase genetic variability within the range of the subspecies in B.C.

4. improve the public's knowledge and awareness of Badgers and increase stewardship of Badgers and Badger habitat
5. address key knowledge gaps that limit recovery implementation.

Although a single-species approach to recovery will be required to address specific concerns related to Badgers, an ecosystem approach to action planning will be adopted as much as possible. The *jeffersonii* Badger Recovery Team endorses and strongly supports the Grassland Action Plan, a cooperative initiative among recovery teams and conservation programs addressing grassland and open forest species and ecosystems at risk in the B.C. Southern Interior. Duplication of effort and competition for limited funding can be avoided by combining efforts, particularly relating to habitat, with other programs. However, species-specific actions are also required. Therefore, Science and Communications & Extension recovery implementation groups (RIGs) have been established. Additional RIGs will be established as required.

Critical habitat has not been identified for Badgers in B.C. Conditions required to maintain at least 400 adults across the provincial range will be identified. A schedule of studies required to identify critical habitat is provided. Action plans that identify critical habitat and recovery actions will be fully developed by or before 2012.

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BACKGROUND

Species Assessment Information from COSEWIC

Date of Assessment: May 2000

Common Name* (population): American Badger, *jeffersonii* subspecies

Scientific Name: *Taxidea taxus jeffersonii*

COSEWIC Status: Endangered

Reason for Designation: Small population, perhaps less than 400 individuals. Fragmented and at risk from roadkill and human development

Canadian Occurrence: British Columbia

COSEWIC Status History: The species was considered a single unit and designated Not at Risk in 1979. Each subspecies was given a separate designation in May 2000. The *jeffersonii* subspecies was designated Endangered. Last assessment based on an updated status report.

* Common names reported in this recovery strategy follow the naming conventions of the British Columbia Conservation Data Centre which may be different from common names reported by COSEWIC.

Description of the Species

Badgers (*Taxidea taxus*) are medium-sized carnivores. Adult males are 60–76 cm long including the tail and weigh up to 12 kg. Adult females are slightly smaller (Long 1973). Badgers are relatively flattened animals with a well-developed pectoral girdle and forelimbs well adapted for digging. The hind limbs are much smaller. Their fur is mottled yellow and tan over most of the body. Distinct white stripes on the head and characteristic “badges” on each cheek give the animal its name.

Populations and Distribution

Global

British Columbia represents the north-western limit of Badger range (Figure 1). Three of four Badger subspecies occur in Canada; only *T. taxus jeffersonii* occurs in B.C. The *jeffersonii* subspecies occurs south into the United States throughout the Great Basin, west of the Rocky Mountains and north of south-western deserts.

Figure 1. Range of the Badger, *Taxidea taxus*, and its four subspecies, in North America. Source: COSEWIC (2000).

There is no population estimate or global rank for the entire *jeffersonii* subspecies of Badger. The global rank for the entire Badger species is G5 (secure; NatureServe 2006). Table 1 summarizes conservation ranks in adjacent jurisdictions. The continental divide marks the boundary between subspecies *T. taxus jeffersonii* and *T. taxus taxus* (Long 1973; Kyle *et al.* 2004).

Table 1. Conservation status rankings (after NatureServe 2008) for Badger in B.C. and adjacent sub-national jurisdictions.

Jurisdiction	Subspecies	Ranking[1]
British Columbia	*T. taxus jeffersonii*	S1
Washington	*T. taxus jeffersonii*	S4
Idaho	*T. taxus jeffersonii*	S5
Montana	*T. taxus jeffersonii* & *T. taxus taxus*[2]	S4
Alberta	*T. taxus taxus*	S4

[1] NatureServe rankings: S5: secure; S4: apparently secure; S3: vulnerable; S2: imperilled; S1: critically imperilled.
[2] British Columbia only borders Montana west of the continental divide in the range of *T. taxus jeffersonii*. Montana does not distinguish between the two subspecies for management purposes.

Canadian

In Canada, *jeffersonii* Badgers occur only in B.C. Their range extends east of the Coastal and Cascade Mountain ranges in the dry Southern Interior of B.C., north to the Cariboo region, and east to the Alberta border (Figure 2). Range does not appear to have changed significantly following settlement (COSEWIC 2000).

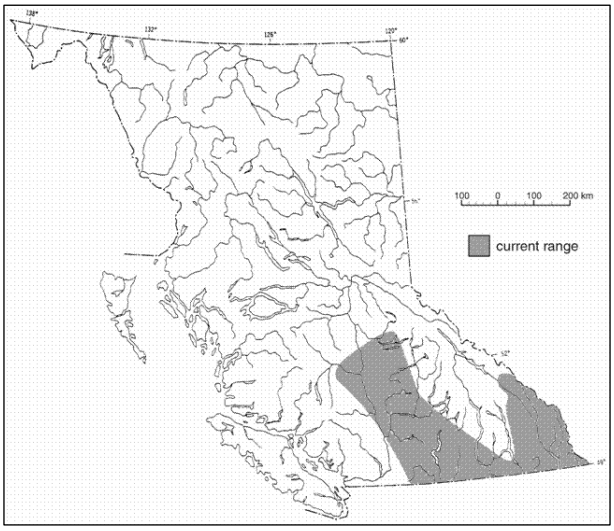

Figure 2. Range of the Badger, *Taxidea taxus,* in B.C. in 1998. Source: COSEWIC (2000).

Badger[1] abundance in B.C. was estimated at 230 - 340 in 2004 (Table 2).

Table 2. Regional population estimates for Badgers in B.C., effective 2004. Estimates are based primarily on research, expert opinion formed from opportunistic live-trapping, public sightings reports, and habitat availability.

Regional Population	Population estimate range	Source
Cariboo	20–45	R. Packham, 2004 pers. comm.
Thompson	40–50	R. Weir, 2004 pers. comm.
Okanagan	25–30	R. Weir, 2004 pers. comm
Nicola	25–30	R. Weir, 2004 pers. comm
Similkameen	10–15	R. Weir, 2004 pers. comm
Boundary	8–10	N. Newhouse and R. Weir, 2004 pers. comm..
East Kootenay	100–160	N. Newhouse, 2004 pers. comm
Total	228–340	

Badger populations in B.C. seem to fit classic models of metapopulations (Hanski and Gilpin 1991). Recent genetic analyses suggest that Badgers in B.C. function as at least two relatively distinct populations. Kyle *et al.* (2004) determined that minimal gene flow was observed between the Thompson-Okanagan and East Kootenay populations. Gene flow did not seem restricted within these two areas. Relatively low levels of genetic variability and genetic exchange with other populations outside of the Thompson-Okanagan suggest that this population is at considerable conservation risk because of its insularity and susceptibility to stochastic events. Kyle *et al*'s (2004) analyses did not include samples from other regions of B.C. and thus relationships to other regional populations are currently unknown. No historical population data exist for Badgers in B.C. However, a long-term decline has almost certainly occurred based on historical trapping records (Figure 3). The number of Badgers trapped annually in the mid-1920s

[1] For this document, subsequent references to "Badger" indicate subspecies *T. taxus jeffersonii*. All other Badger species or subspecies of *T. taxus* will be otherwise identified.

was greater than current population estimates. Trap returns remained very low after the 1940s, although there are no data on trapping effort for Badgers over these time periods.

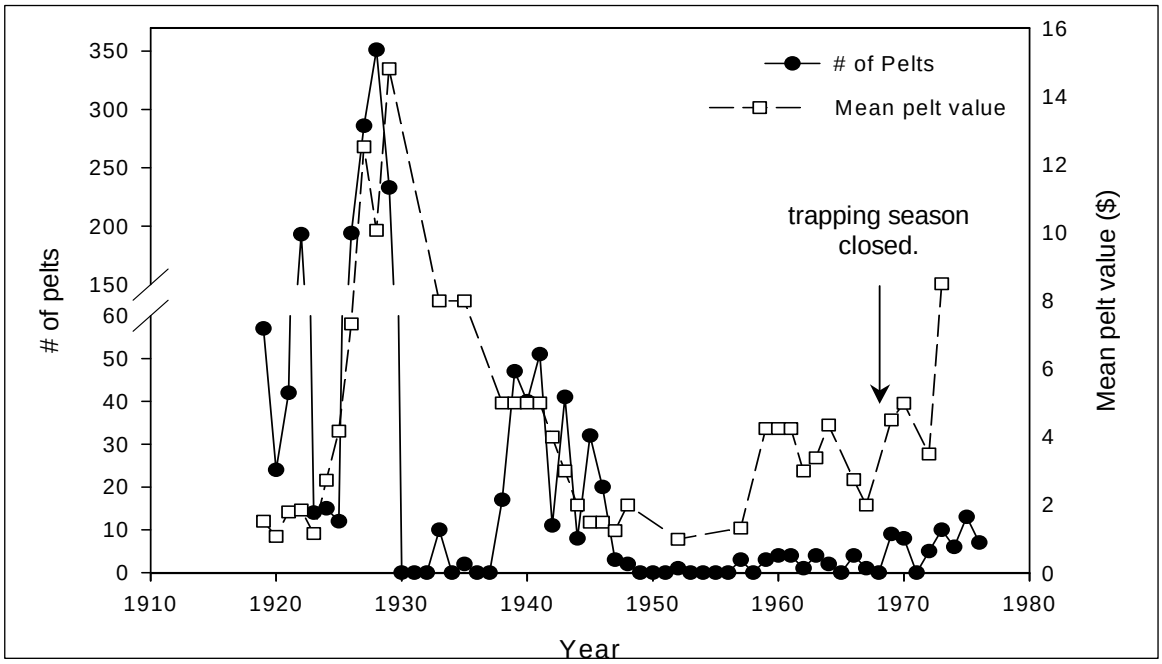

Figure 3. Annual number of Badger pelts traded in B.C. and average pelt value, 1919–1920 to 1976–1977. Badger trapping season closed in 1967. Harvest after this time was likely incidental. Note left axis splits, right axis does not.

The B.C. Badger population has likely declined further over the past two decades. They were extirpated from the Upper Columbia Valley of the East Kootenay region after 1996 (Newhouse and Kinley 2000). Indirect evidence of recent declines in B.C. includes:

- Low number of juvenile captures. Between 1996 and 2002 in the East Kootenays, 13 of 34 (38%) Badgers captured by researchers were juveniles (Newhouse and Kinley 2004). In the Thompson region, only 1 of 13 (8%) study animals and 1 of 7 (14%) road-killed Badgers were juveniles (R. Weir, unpublished data). By comparison, other studies of stable or increasing Badger populations report that approximately 50% of captures are juveniles (Messick and Hornocker 1981; Warner and Ver Steeg 1995). Todd (1980) noted that the juvenile cohort in a population of Badgers in Idaho comprised 44% of the population.
- Low number of female captures in certain regions. In the Thompson region, 2 of 13 study animals were females (Weir *et al.* 2003). In the Cariboo region, Hoodicoff and Packham (2006) detected 14 females compared with 21 males at burrow sites. In the East Kootenay, however, an equal number of males and females were captured (Newhouse and Kinley 2004), which is similar to that reported for Idaho (1.2 males per female; Todd 1980).
- Anecdotal reports of Badgers from landowners in the Thompson and Okanagan indicate that Badgers have been seen less frequently over the past 20 years (R. Weir, unpubl. data).

On a positive note, recent research in the Cariboo region suggests the Badger population there may be increasing as Badgers are now being observed in areas where they have not been seen in decades (Packham and Hoodicoff 2007).

Needs of the Badger

Habitat and biological needs

Rahme *et al.* (1995) list only two known requirements for Badgers: suitable soil for digging, and prey. Badger habitat requirements may otherwise be very plastic. Research in B.C. has found Badgers in many environments — from hot, dry grassland valley bottom to alpine tundra. However, preferences seem to be for grasslands/fields or open-canopied forests (Apps *et al.* 2002; Hoodicoff 2003; Weir *et al.* 2003).

Soil coherence[2] affects site selection by Badgers (Rahme *et al.* 1995; Weir *et al.* 2003). Apps *et al.* (2002) examined the effects of a suite of environmental variables on site selection at broad (28.3 km²) and moderate (0.14 km²) spatial scales. Most selection was expressed at a broad scale, with fewer variables being important at the moderate scale. Badgers in the East Kootenay selected sites at the broad scale on the basis of soil parent material, soil type ("order-association"), soil texture and habitat type. Badgers at this scale were positively associated with glaciolactustrine and glaciofluvial parent materials, brunisols and regosols, soils with sandy loam textures and open range, agricultural habitats and linear disturbances (Apps *et al.* 2002). At this scale they were negatively associated with colluvial parent materials, podzol and luvisol soils, forested habitats, and increasing elevation, slope, terrain ruggedness, vegetation productivity and moisture. At the moderate scale Badgers were positively associated with glaciofluvial, fine sandy-loam textured and well drained soils and negatively associated with forest cover, vegetation moisture, elevation and terrain ruggedness (Apps *et al.* 2002). Weir *et al.* (2003) determined that Badgers in the Thompson region selected fine scale patches within ecosystem units that were characterized by silty soils with low coarse fragment content and high concentrations of prey sign. Conservation of patches and ecosystem units with these features is expected to be important for the continued persistence of Badgers in the Thompson and Okanagan regions. In the Cariboo region, Badgers mostly use aeolian and lacustrine soil for burrowing (Packham and Hoodicoff 2004a).

Weir (2006) is developing a conservation assessment using a Bayesian Belief Network (Marcot *et al.* 2001) that will be used to predict Badger population response to different land management decisions. This assessment process will link various habitat features to provide an explicit description of Badger habitat requirements and will be a key step in describing critical habitat.

As wide-ranging medium-sized carnivores, Badgers require substantial tracts of suitable habitat to maintain viable populations. The three biogeoclimatic zones (Meidinger and Pojar 1991) most

[2] Many authors list "friable" soil as a key attribute of Badger habitat. Bill Chapman (pers. comm.) notes that "soil friability has a very specific technical meaning, i.e., when gentle pressure is applied to a clod of friable soil, it neither molds nor pulverizes, but rather crumbles." This does not reflect the soil conditions required by Badger for digging. The soil that Badgers seek is better referred to as "coherent coarse silt to fine sand," where "coherent" conveys the concept that the soil does not collapse when burrowed.

preferred by Badgers are Bunchgrass, Ponderosa Pine, and Interior Douglas-fir. Although Badgers (and their prey) will use other zones, their highest densities occur in these areas.

Ecological role

The Badger is the only fossorial (adapted to digging) carnivore in the grassland and open forest ecosystems of B.C.'s Southern Interior. Burrows dug by Badgers form important habitat components for other species, such as Burrowing Owl (*Speotyto cunicularia*), Western Rattlesnake (*Crotalus oreganus*), and Gopher Snake (*Pituophis catenifer*) that use abandoned burrows for nesting sites or thermal cover. Badger digging and associated mounds are important features of grassland and open forest ecosystems. This activity influences a wide range of processes including water infiltration, soil aeration, decomposition rates, vascular plant diversity, and support for various soil invertebrates (Eldridge 2004).

Badgers are opportunistic hunters, preying on various animals (Messick 1987). Gut and scat analyses from the East Kootenay, Thompson, and Cariboo regions have revealed that Badgers consume Columbian Ground Squirrel (*Spermophilus columbianus)*, Yellow-bellied Marmot (*Marmota flaviventris*), Northern Pocket Gopher (*Thomomys talpoides*), Muskrat (*Ondatra zibethiucs*), leporids (rabbits and hares), various microtine rodents (e.g., voles), insects, birds, reptiles, amphibians, and fish (Newhouse and Kinley 2000; Hoodicoff 2003; Packham and Hoodicoff 2004a, 2004b). Birds and fishes are likely rare occurrences, although Badgers could be regular nest predators of ground-nesting birds. Small mammals, particularly Columbian Ground Squirrels, form the majority of the Badger diet. Where they occur, Yellow-bellied Marmots are also an important prey species. Northern Pocket Gophers are found throughout much of the Badger's range in B.C., but their role as a prey species appears to be relatively minor (Hoodicoff 2003). Potential predators include Coyote (*Canis latrans*), Grey Wolf (*Canis lupus*), domestic dog (*Canis familiaris*), Bobcat (*Lynx rufus*), Cougar (*Puma concolor*), Raven (*Corvus corax*), and large raptors (Messick 1987; (Newhouse and Kinley 2004). Adult Badgers are rarely predated.

Limiting factors

The primary factors limiting Badger populations in B.C. are believed to be related to road mortality, habitat, and prey constraints (Newhouse and Kinley 2000), although the exact effects of modification, alienation, and loss of habitat on Badger populations in the province are largely unknown. Individual Badgers need habitats with suitable densities of prey and appropriate substrates in which to dig burrows (Rahme *et al.* 1995) and appear to base most of their habitat decisions on these features (Apps *et al.* 2002; Weir *et al.* 2003). Badger recovery may also be limited by a number of inherent demographic parameters.

Reproductive capacity
Low reproductive capacity may affect Badger population recovery as it does other mustelid populations (Ruggiero *et al.* [eds.] 1994; Rahme *et al.* 1995; Weaver *et al.* 1996). Females can start breeding in their first season, but only 30–50% do so (Messick and Hornocker 1981). In the East Kootenay, two of four females that were over 1 year of age had litters (Newhouse and

Kinley 2004). Males do not mature sexually until over 1 year of age (Messick 1987), but are not thought to contribute significantly to reproduction until more than 4 years old.

Reproductive capacity may also be limited by other means. Badgers are believed to be induced ovulators and ovulation may require multiple copulations (Messick and Hornocker 1981; Minta 1993). In addition, rates of fertilization may be increased by the number of copulations and male fitness (Messick and Hornocker 1981). Consequently, repeated copulations with experienced males may be necessary for fertilization to occur. Badgers also exhibit delayed implantation that may be triggered by environmental conditions and prey availability (Messick 1987). If breeding opportunities are limited by low densities of mates (and therefore reduced encounters) and food sources are unreliable, overall reproductive output at the population level could be limited. Badger litter sizes across North America vary from one to five (Lindzey 1982). Litter sizes tend to decrease toward the northern limits of their range (Table 3) (Newhouse and Kinley 2004). Fecundity may increase with age (Todd 1980).

Table 3. Summary of Badger litter sizes in B.C. For sightings data, all Badger groups observed are assumed to be one female with kits (litter size = group size – 1).

Location	N[1]	Mean	Range	Source
East Kootenay	17	1.7	1–3	• radiotelemetry: 1996–2006 • Kinley and Newhouse 2008
	129	2	1–4	• sightings: 1996–2008[2] • Kinley and Newhouse (2005) and Kinley (unpublished data)
Thompson-Okanagan	57	1.6	1–4	• sightings: 1996–2008
	2	1.5	1-2	• radiotelemetry: 1999-2002 • R. Weir (unpublished data)
Cariboo	11	2.0	1–4	• R. Klafki and R. Packham (radio-telemetry and unpublished sightings data)

[1] Total number of litters observed.
[2] Does not include unconfirmed sighting of five Badgers (assume mother with four kits) near Elkford, B.C., in 2001.

Females are capable of producing one litter each year, but data suggest this is rare in B.C. In the East Kootenay, 16 adult females fitted with radio-transmitters were monitored for 1 to 4 years, representing 33 possible litters. However, only 17 litters were observed and contribution to breeding was not even among females (Newhouse and Kinley 2008).

Juvenile survivorship

Recruitment of juveniles into the adult population can be compromised by low juvenile survivorship. Coyotes, Bobcats, Cougars, Ravens, and Golden Eagles (*Aquila chrysaetos*) are all reported to prey on juvenile Badgers (Rahme *et al.* 1995 and references therein; Weir *et al.* 2003). In the East Kootenay region, annual survival rate for radio-tagged Badgers to 1 year of age was 55% (n = 11 juveniles; 4 M, 7 F). In contrast, annual survival rate for adults over the same period was 81% (n = 21 adults; 11 M, 10 F; Newhouse and Kinley 2004). Both rates are comparable to other studies (Warner and Ver Steeg 1995; Hoff 1998) and are likely similar elsewhere in B.C. Whether low recruitment of juveniles into the adult population limits the ability of Badgers to repopulate areas following a decline is unknown.

Home range size
Minta (1993) showed that the density of females dictates male home range size. Where female numbers are high, males need not range far for breeding opportunities. It is believed that food availability limits female home range size (Minta 1993; Goodrich and Buskirk 1998).

Badgers have much larger home ranges in B.C. than elsewhere (Table 4). Factors contributing to this difference may include low prey densities (food searching) and low Badger densities (mate searching). Increased movement associated with large home ranges may expose individuals to increased mortality risk from highways and predation. Extensive movements also increase energy requirements and therefore pose even greater food searching requirements. Another conservation implication to large home range size is that multiple observations of one individual over a large area may be mistakenly assumed to be several Badgers, leading to overestimates of population size (Newhouse and Kinley 2000).

Table 4. Mean home range sizes (km^2) of male (M) and female (F) Badgers in North America.

	MCP[1]		95% FK[2]		Sample size (N)		Source
Location	**M**	**F**	**M**	**F**	**M**	**F**	
Illinois	44	13			6	7	Warner and Ver Steeg (1995)
NW Utah	5.8	2.4			2	5	Lindzey (1978)
Wyoming	3	8			18	15	Minta (1993)
Wyoming			12	3.4	8	6	Goodrich and Buskirk (1998)
SW Idaho	2.4	1.6			2	3	Messick and Hornocker (1981)
B.C.: East Kootenay	315	34.2	67.1	17.4	9	7	Newhouse and Kinley (2004)
B.C.: Thompson	87.9	10.5	32.7	15.6	8	1	Weir *et al.* (2003)

[1] Minimum convex polygon of all locations
[2] 95% fixed kernel method

Northern range limit
Individuals at the periphery of their range tend to be more at risk from stochastic events than core populations. Due to their smaller size and isolation, peripheral populations tend to have lower genetic diversity and show greater differentiation due to genetic drift than do core populations (Lesica and Allendorf 1995). Kyle *et al.* (2004) determined that Badgers from the Thompson and Okanagan regions were much less genetically diverse than Badgers from elsewhere. Although novel selection pressures facing peripheral populations may advance evolution (Fraser 2000), peripheral populations experience more fluctuation in numbers. Further, reintroductions or augmentations to help offset such fluctuations are less likely to succeed at the edge of a species' range than at its core (Griffith *et al.* 1989; Wolf *et al.* 1996).

Threats

Overarching threats to Badger populations are those intrinsically associated with stochastic and demographic implications to small fragmented populations. Small isolated populations are inherently at higher risk of extirpation or extinction due to stochastic phenomena and demographic uncertainty (Shaffer 1981). Kinley and Newhouse (2008) describe some limitations to Badger recovery posed by small populations in the East Kootenay region of B.C. Continuing and historic threats that limit Badger population size and distribution are outlined in Table 5.

Table 5. Probable, continuing, and historic threats to Badger populations and habitats in B.C. Threats are ranked by relative impact (predominant, contributing, or minor), spatial distribution (widespread or local), temporal impacts (chronic, episodic, or ephemeral), and status of threat abatement.

Threat	Impact	Spatial	Temporal	Abated?
Habitat loss & degradation:				
• urban/rural/highway development	predominant	widespread	episodic	no
• forest in-growth & encroachment	contributing	widespread	chronic	partially
• poor range management	contributing	local	chronic	no
• reservoir flooding	contributing[1]	local	chronic	no
• agricultural cultivation	minor	widespread	chronic	no
• viticulture & orchards	minor	local	chronic	no
Road mortality	predominant	widespread	chronic	no
Trapping	predominant	widespread	episodic	yes
Persecution	contributing[2]	widespread	chronic	partially
Loss of prey	contributing	widespread	episodic	no
Secondary poisoning via prey	minor	local	ephemeral	partially

[1] Across all of B.C., reservoir flooding has likely had limited impact on population numbers. However, at a local level, impacts are likely predominant (e.g., Koocanusa Reservoir in southern Rocky Mountain Trench).

[2] Degree of persecution is unknown. Impact is potentially substantial at a local level.

Description of threats

Habitat loss and degradation

Habitat loss refers to the alteration of wildlife habitat to the point of being unusable by a given species (Hunter 1996). For Badgers, urban development represents the greatest cause of habitat loss. Degradation of Badger habitat, a less dramatic decline in quality (Hunter 1996), often results from agricultural development or from forest encroachment onto grasslands. Although the overall geographic range of Badgers in B.C. may not be significantly reduced, substantial habitat loss and degradation have occurred within this range over the last 50 years in what was likely the best Badger habitat in B.C. — grassland and open forest valley bottoms. The three biogeoclimatic zones most preferred by Badgers (Bunchgrass, Ponderosa Pine, and Interior Douglas-fir) are among the most poorly represented by protected areas in B.C. and under the most intense development pressure. Thus, the area of occupancy has likely diminished considerably within the range of the species in the province.

Badgers can use areas that have been modified by humans and tolerate some level of human activity (Weir *et al.* 2003). Many sites currently unoccupied by Badgers that have human activity are considered degraded habitat rather than permanently lost. Development pressures within Badger habitats in B.C. have increased greatly in recent decades, particularly within the grassland valleys of the Thompson, Okanagan, and Kootenay regions. Urban, rural, and industrial development and associated commercial, recreational, and highway development cause most grassland habitat loss (GCC 2005). They have and continue to result in the loss and degradation of significant components of important Badger habitat and have contributed to increased risk due to other threats (see “Road mortality” section below).

Fire suppression throughout much of B.C.’s Southern Interior has fostered the growth of young forests that were historically burned by frequent low-intensity fires (Table 6; Gayton 2001). In-grown areas tend to be dense stands of small diameter Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) that support much-reduced biodiversity (Gayton 2001),

including reduced prey populations. The resulting increase in forest canopy closure may reduce habitat quality for prey species. Research in B.C. has shown Badgers do use forested landscapes (Apps *et al.* 2002; Hoodicoff 2003; Weir *et al.* 2003), but this is limited to areas where prey populations are plentiful and usually associated with coherent coarse silt to fine sand soil types following logging or wildfire disturbance.

Table 6. Regional estimates of forest in-growth and encroachment in southern B.C. forest regions. Source: Kirby and Campbell (1999).

	Kamloops Forest Region			**Kootenay Forest Region**		
	In-Growth 6–15%[1]	In-Growth 16–65%[1]	Encroachment	In-Growth 6–15%[1]	In-Growth 16–65%[1]	Encroachment
Total area (ha)	46,712	190,891	18,852	32,082	101,173	30,154

[1] Percent crown closure of forest stand.

Livestock grazing can affect Badger habitat and prey populations, particularly where Columbian Ground Squirrels are absent. In these areas (e.g., Cariboo region), Badgers rely on various small mammal prey, which themselves rely on well-structured grasslands. Range practices that degrade grasslands (e.g., over-utilization of range resources) indirectly threaten local Badger populations via their prey.

In many parts of Badger range in B.C., valley bottom habitat has been flooded for hydroelectric development. This is particularly true in the southern Rocky Mountain Trench where 187 km^2 of grassland and open forest in both B.C. and adjacent Montana were flooded in 1974 above the Libby Dam to form the Koocanusa Reservoir (B. Gammer, 2002 pers. comm.). Sixty-four km^2 of this flooded area is in Canada. The southern Rocky Mountain Trench still maintains one of the highest densities of *jeffersonii* Badgers in Canada, but it has been degraded from its original state. Reservoirs also fragment remaining Badger habitat. Badgers are known to cross large rivers, including the North and South Thompson rivers near Kamloops (Weir *et al.* 2003). However, flooded reservoirs such as the Koocanusa Reservoir likely represent movement barriers.

Agricultural cultivation (forage crops) contributes to habitat degradation, but is less likely to result in complete loss of habitat. Grassland areas cultivated for forage production remove grassland vegetation and alter soil structure (GCC 2005) important to Badgers and their prey. Viticulture and orchards are currently prominent and growing rapidly within the Okanagan Valley, resulting in conversion of Badger habitat in native grasslands to intensively cropped lands with little value to Badgers.

Road mortality

Road mortality on highways is the single leading cause of mortality for Badgers in B.C. (Newhouse and Kinley 2004; Weir *et al.* 2004b) and elsewhere (Messick 1987). Badgers with home ranges that span major transportation corridors have high encounter rates with roads and highways (Weir *et al.* 2003). The survivorship of Badgers in the Thompson region seems to be related to the frequency of road crossings and the density of paved roads within their home ranges (Weir *et al.* 2004b). In the Thompson region, 86% of known mortalities of radio-tagged Badgers were attributed to roadkill (Table 7). Most of these mortalities occurred in July when

traffic volumes peaked and Badger movements were greatest. Badgers in the East Kootenay were found closer to paved roads than expected (Newhouse and Kinley 2000). In spite of similarities in Badger movements and road locations, the East Kootenay region has less traffic than the Thompson region and road mortality appears to be less common (4 of 32 radio-tagged Badgers; Newhouse and Kinley 2004), suggesting that susceptibility of Badgers to road mortality may be related to traffic volume. In the Cariboo, 18% of the Badger study population was killed by vehicles in a 4-year period (Packham and Hoodicoff, unpubl. data). Similar to the Thompson region, most roadkill in the Cariboo also occurs in July. Roadkill is also of concern to American wildlife managers (B. Ruediger, 2002 pers. comm.). Lyle Lewis (2002 pers. comm. to B. Ruediger) observed 100 road mortalities within six months on a 65-km stretch of highway near Boise, Idaho.

Table 7. Causes of Badger mortalities from southern Idaho and B.C. For East Kootenay and Thompson-Okanagan studies percentages are based on the sample of radio-tagged Badgers. Probability of observing mortality in non-radio-tagged Badgers (Idaho data and additional known roadkill data) is strongly biased toward highway roadkill.

Location (Source)	Cause	N	%
Idaho (Messick 1987)	Killed by local residents	94	60
	Roadkill	52	33
	Natural/Unknown	11	7
East Kootenay (Newhouse and Kinley 2004)	Natural/Predation/Unknown	9	64
	Road Kill	4	29
	Rail Kill	1	7
	Additional known roadkill	12	-
Thompson-Okanagan (Weir *et al.* 2003)	Roadkill	6	86
	Natural/Predation/Unknown	1	14
	Additional known roadkill	13	-

Badgers are attracted to and vulnerable on highways for several reasons:

- Prey species such as Columbian Ground Squirrels and Yellow-bellied Marmots often frequent grasses and coherent coarse silt to sand soils characteristic of roadside environments, which may subsequently attract Badgers (Weir *et al.* 2003).
- In many regions, Badgers prefer valley bottoms, where highways are most often constructed.
- Badgers have large home ranges and peak seasonal movements coincide with peak traffic volumes on highways.
- Banks created by road construction are attractive to Badgers because less energy is expended during burrowing.
- Badgers are most active at night, when drivers have most difficulty seeing a relatively small, low-to-the-ground animal.

Mitigation may be difficult. Because Badgers maintain large home ranges, it is currently difficult to predict road crossing areas, reducing the efficacy of speed reductions or alternative crossing structures. Further, motorists do not generally comply with speed restrictions. Concrete barriers on highways compound the threat to Badgers. Weir *et al.* (2003) cite reports of Badgers running along the roadside trying to get around such barriers. Several Badgers in the Thompson region

were eventually killed on a highway with continuous stretches of concrete barrier. Badgers will use underground crossings such as culverts where these are available (R. Klafki, 2004 pers. observation). Current understanding of Badger use of habitat near roads and crossing areas is not well enough understood to address this threat effectively. Research is underway to address this.

Grain spills on railways may attract Badger prey, and thus Badgers. Although railway mortality has been recorded (Weir *et al.* 2004b), it occurs at a much lower rate than on highways and is considered to be a significantly lower threat.

Trapping
Commercial harvest of Badgers likely contributed to the initial decline of the B.C. population (Figure 3). Trapping seasons have been closed across the province since 1967. Badgers may occasionally be caught in traps set for other species, such as Coyotes (Rahme *et al.* 1995). Provincial regulations require trappers to surrender all by catch species with closed trapping seasons. Only 16 Badgers have been reported trapped since the season was closed.

Persecution
Persecution is defined here as the illegal killing of Badgers. This activity remains a threat to Badgers. Badgers are known to use urban interfaces and are reasonably tolerant of human presence. They readily use roadside berms to excavate burrows and sightings from B.C. include golf courses, ranches, ginseng farms, mining operations, and ski hills. Many landowners remain intolerant of Badgers on their property, citing damage to irrigation and cultivation equipment caused by digging. Others perceive Badgers to be aggressive and fear them.

Extensive persecution in adjacent American states, where Badgers are regularly perceived as nuisance animals (Table 7; J. Williams, 2002 pers. comm.), is a concern for *jeffersonii* Badgers in Canada because it may decrease dispersal rates from the U.S. to Canada. There is a need to assess the state of the subspecies as a whole and then approach jurisdictions for help with conservation.

Loss of prey and secondary poisoning via prey
Badgers in B.C. are closely tied to the prey species that form the bulk of their diet (Columbia Ground Squirrels and Yellow-bellied Marmots). Most Badger burrows have ground squirrel burrows close by (Messick 1987; Newhouse and Kinley 2000). Prey species, ground squirrels in particular, are often the subject of intense extermination programs by landowners.

Landowners control burrowing rodents largely through shooting (Weir *et al.* 2004a). Schedule "B" of the *B.C. Wildlife Act* lists species "that may be captured or killed only for the specific purpose of protecting private property." Badger prey species included on this list are Columbian Ground Squirrel, Yellow-bellied Marmot, Northern Pocket Gopher, and all arvicolid rodents (e.g., voles). There are also year-round open hunting seasons with no bag limit on Columbian Ground Squirrels in Regions 3, 4, and 5 (Figure 4). Although shooting is the most common form of control, use of rodenticides is also very common (Weir *et al.* 2004a), which may result in secondary poisoning of Badgers.

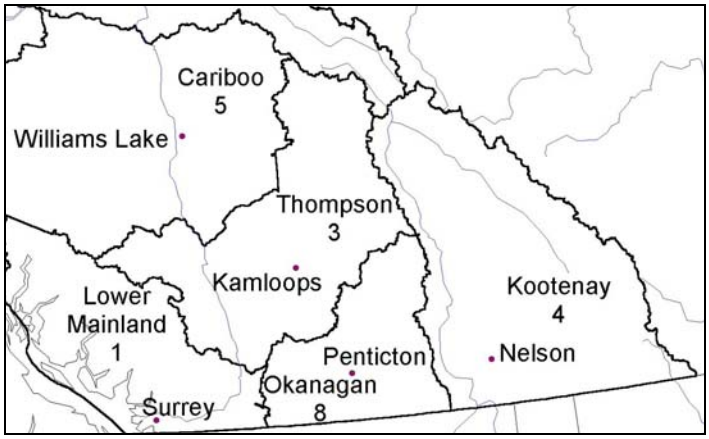

Figure 4. Southern administrative regions for B.C. Ministry of Environment. Badgers are known to occur in Regions 3, 4, 5, and 8.

Human activities can have considerable effect on the availability of prey for Badgers. Development and range and agricultural practices likely affect Badger prey the most. Especially in areas where Columbian Ground Squirrels are absent, Badgers may rely on alternate prey species (e.g., microtine rodents) that require grassland communities with considerable grass structure and carryover. In some areas, commercial logging may benefit Badgers by increasing open, early successional forests preferred by Columbian Ground Squirrels and other prey. There are two potential negative effects of reductions in the availability of prey on Badgers:

1. Direct loss of food resources
   Most badger prey species also reach their northern range limits in southern B.C. and, though locally common to abundant, are not distributed evenly across the province's Badger range. Their ecology is not well understood. The extent to which Badgers are food-limited is not directly known, but is speculated to be substantial. Reducing prey populations, via poisoning or shooting, may further limit Badger populations and force greater movements to find adequate food resources.
2. Secondary poisoning
   Scavenging dead rodents killed by poison may indirectly affect Badgers (Rahme *et al.* 1995). Rodenticide may be transferable to predators from poisoned animals with subsequent deleterious effects. The likelihood and possible extent of this are unknown.

Actions Already Completed or Underway

The *jeffersonii* Badger Recovery Team was formed in April 2001 and has met annually since then. Team activities have included strategy preparation, research projects, and conservation planning. In the last 10 years, Badgers in B.C. have been studied substantially. This work is summarized in Appendix 1. Science and data needs identified by the science recovery implementation group (RIG) (see "Knowledge Gaps" and Appendix 2) have guided and facilitated research activities.

Supporting recovery of the Badgers in B.C. has been the establishment of Wildlife Habitat Areas, under B.C.'s Identified Wildlife Management Strategy (Province of BC 2004).

Concerted efforts have been made towards public outreach, but a formal communications and extension plan has not been prepared. The communications and extension RIG undertook a "logic modelling" process in 2002 to help direct outreach and other recovery activities. This model (available at <www.badgers.bc.ca>) outlines actions needed to meet short to long term outcomes for badger recovery and has informally guided recovery team actions since its development.

Knowledge Gaps

The science RIG has identified the following areas in which additional science and data are needed to effectively recover *jeffersonii* Badger populations:

- mortality factors;
- prey ecology;
- diet;
- distribution and abundance;
- inventory development and methodology;
- population ecology, meta-population structure, and genetics;
- monitoring;
- atypical habitat; and
- stewardship.

A full description of these knowledge gaps, as well as specific research questions, needs, and actions undertaken to date, are outlined in Appendix 2.

RECOVERY

Recovery Feasibility

Recovery of Badgers in B.C. is challenged by the over-arching threat of risks of small populations to stochastic phenomena. Recovery of Badgers in B.C. is ecologically and technically feasible. It will require a reduction in road mortality and habitat loss, adequate protection to individuals from wilful killing, and augmentation or reintroduction of populations when required.

1. Individuals capable of reproduction are available to support recovery in most, but not necessarily all, locations. Areas of concern include the Thompson and Upper Columbia valleys.
2. Sufficient habitat is probably currently available to support recovery in most regions. Areas of concern include the Thompson and Okanagan valleys where development pressures are greatest.
3. Some threats to Badgers and their habitat may be avoided or mitigated through recovery actions, though the extent to which actions will be successful is unknown.
4. The necessary recovery techniques (e.g., habitat protection and restoration, development of road crossing structures, land acquisition programs, and conservation covenants) exist and

are known to be effective. No highly experimental techniques are required to recover the species.

Anticipated conflicts or challenges
Recovery may be impeded by the following:

- high road mortality: traffic volumes are projected to increase, mitigation will likely be expensive, and success rates are currently uncertain;
- limited reproductive capacity of the species;
- low juvenile survivorship;
- small naturally isolated populations with unknown amounts of movement between them;
- habitat loss is expected to continue;
- options for habitat restoration in much of their range are limited; and
- lack of dedicated funding.

Recovery Goal

The long term goal is to achieve and ensure a viable population of Badgers throughout their historic range in B.C. The 5-year goal is to increase the total Badger population in B.C. to a minimum of 400 adults.

Rationale for the Recovery Goal

The 5-year goal of 400 Badgers represents a population increase that may be attainable through natural population growth, inventory of un-surveyed areas, reduction in road mortality, and population augmentation. Achieving the long term goal will require improved broad-based public stewardship support, dedicated resources and an improved knowledge base.

Recovery Objectives

Short-term (5-year) recovery objectives are intensive management objectives that are (1) deemed necessary to ensure continuation of the species in B.C.; and (2) designed to increase our understanding of the ecological role and functioning of Badgers. In most cases, specific targets have not been identified for recovery objectives due to a lack of information necessary to quantify a baseline on which to measure these or a current inability to describe the necessary targets. For example, the relationship between Badger habitat quantity and quality and Badger density is unknown, thus it is not currently feasible to identify the amount of habitat necessary to meet 5-year population recovery objectives. Thus, in cases where recovery objectives are not currently quantified, they have been characterized as directional (i.e., more, less, greater, fewer). All recovery objectives are targeted to be completed within the 5-year time frame. Recovery actions and performance measures are outlined in the “Description of the recovery planning table” section for each or the following objectives:

1. ensure suitable quality and quantity of habitat for Badgers and their prey;
2. increase Badger survivorship and recruitment;

3. maintain or increase genetic variability within the range of the subspecies in B.C.;
4. improve the public's knowledge and awareness of Badgers and increase stewardship of Badgers and Badger habitat; and
5. address key knowledge gaps that limit recovery implementation.

Approaches Recommended to Meet Recovery Objectives

Recovery planning table

Approaches to meet recovery objectives are outlined in Table 8.

Table 8. Recovery planning table for Badger, *jeffersonii* subspecies.

Priority	Threat(s) addressed[1]	Broad strategy to address threat(s)	Recommended approaches to meet recovery objectives
• **Objective 1: Ensure suitable quantity and quality of habitat for Badgers and their prey**			
Urgent	• Urban/rural/highway development • Poor range management • Agricultural cultivation • Viticulture & orchards	• Habitat protection • Stewardship	• Increase voluntary protection of Badger habitats by landowners and land managers • Use appropriate legislative tools to protect habitat on Crown lands • Increase the consideration given to Badger habitat conservation during strategic and operational land use planning • Promote the use of covenants, easements, tax incentives, and stewardship agreements • Support and encourage conservation land acquisition
Urgent	• Forest in-growth & encroachment	• Intensive site and landscape management	• Increase grassland and open forest restoration
• **Objective 2: Increase Badger survivorship and recruitment**			
Urgent	• Road mortality	• Site management	• Increase the likelihood of Badgers safely crossing roads • Decrease habitat suitability near roads for Badgers and their prey • Translocate Badgers where necessary
Necessary	• Persecution • Loss of prey	• Stewardship • Law enforcement	• Increase the appreciation of Badgers and their prey • Increase protection of Badgers
• **Objective 3: Maintain or increase genetic variability within the population**			
Beneficial	• Habitat loss & degradation • Road mortality • Persecution • Loss of prey	• Landscape management • Intensive management	• Facilitate increased movement among Badger populations • Work with adjacent U.S. states to ensure robust potential source populations
• **Objective 4: Improve the public's knowledge and awareness of Badgers and increase stewardship of Badgers and Badger habitat**			
Urgent	Many	• Stewardship and education	• Refine the Badger logic model to improve communication about badger recovery activities • Complete and implement a comprehensive communications and outreach plan
• **Objective 5: Address key knowledge gaps that limit recovery implementation**			
Necessary	Many	• Research and monitoring	• Identify and prioritize science and data needs required to support Badger recovery • Engage universities, private consultants, and funding agencies to initiate priority research and monitoring projects

[1] See Table 5 for outline of threats.

Description of the Recovery Planning Table

Some previously mentioned threats are not addressed in this section as they are either irreversible or already mitigated (e.g., reservoir flooding, trapping, and existing urban settlement). Recovery objectives and performance measures are stated within the 5-year time frame.

Objective 1: Ensure suitable quality and quantity of habitat for Badgers and their prey
Habitat protection for Badgers and their prey will be sought through the implementation of legislative and regulatory tools and through voluntary actions brought about through stewardship and outreach activities to increase knowledge and appreciation of Badgers and their habitat. Overall restoration and maintenance of grassland and open forest ecosystems in southern B.C. is essential for Badger recovery (and numerous other species at risk). Various organizations, in partnership with the *jeffersonii* Badger Recovery Team, will undertake many of these actions.

Increase voluntary protection of Badger habitats by landowners and land managers
Organizations such as the B.C. Cattlemen's Association, the Grassland Conservation Council of B.C., the Real Estate Board of B.C., and other bodies may help facilitate this.

- *Help landowners and land managers gain a better appreciation for Badgers and their ecological role in maintaining healthy grassland ecosystems.*
- *Help landowners and land managers identify Badger habitat on their property through Stewardship Support Manuals that provide a pictorial guide to habitat identification.*
- *Provide landowners and land managers with simple tools to conserve Badger habitat on their property.*
- *Increase number of contacts between landowners and land managers who support Badger habitat conservation and other landowners and land managers.*

Performance measures
Because this approach is voluntary, occurs on private lands, and can take many different forms it is very difficult to directly measure performance. The following are indirect measures of performance which pertain to actions identified above to facilitate improved voluntary habitat protection:

1. Identified and contacted landowners and land managers with Badger habitat.
2. Produced and distributed stewardship materials to landowners and land managers.
3. Conducted workshops and Badger conservation demonstration projects to facilitate communication between supportive landowners and land managers and their peers.

Use appropriate legislative tools to protect habitat on Crown land

- *Use Wildlife Habitat Areas (WHAs) and Wildlife Habitat Feature provisions (see Province of BC 2004) under the* B.C. Forest and Range Protection Act.
- *Apply, under the* B.C. Land Act*, to prevent alienation (sale, development) of key habitats.*
- *Ensure residence protection by listing under the* B.C. Wildlife Amendment Act, 2004.

Performance measures

1. Established a minimum of five WHAs in each region represented by a recovery implementation group (Kootenay, Okanagan, Thompson, and Cariboo, see "Recovery Implementation Groups" section for RIG details).

2. Incorporated Badger habitat requirements into all Range Use Plans/Range Stewardship Plans within Badger range.
3. Listed badgers under the *B.C. Wildlife Amendment Act, 2004.*

Increase the consideration given to Badger habitat conservation during strategic and operational land use planning

- *Increase discussion about Badger habitat needs at strategic and operational planning tables.*
- *Encourage use of* Community Charter *provisions to protect Badgers, their habitat, and their residences on private land within municipalities.*

Performance measures

1. Included Badger habitat requirements in all land use planning exercises for areas where Badgers are known to exist. Examples include Land Resource Management Plans (LRMPs), Official Community Plans (OCPs), and Range Use Plans.
2. Provided municipal and regional governments in Badger habitat with tools to address Badger habitat in their jurisdictions.

Promote the use of covenants, easements, tax incentives, and stewardship agreements

Much of the suitable habitat for Badgers in B.C. occurs on private lands. Tax incentives for landowners that encourage the presence of Badgers or other species at risk on their property are poorly known or understood by landowners. Incentives are currently available through conservation easements and covenants. More direct tax incentives would be beneficial.

- *Increase the knowledge of conservation easement and covenant opportunities among landowners.*
- *Facilitate the establishment of conservation covenants by non-government organizations.*
- *Support and encourage legislative and regulatory initiatives that provide tax incentives for landowners that maintain or support species at risk on their property.*

Performance measures

1. Supported private land covenants, easements or private land stewardship agreements that protect Badgers and Badger habitat in cooperation with regional conservation programs.
2. Supported regulatory and legislative initiatives for conservation tax incentives.

Support and encourage conservation land acquisition

Outright purchase of lands supporting Badgers is another means to protect and maintain habitat. The *jeffersonii* Badger Recovery Team does not propose to purchase lands, but will support by whatever means possible those organizations that are involved in this activity (e.g., The Land Conservancy of B.C., The Nature Trust of B.C., Nature Conservancy of Canada).

- *Support conservation organizations involved with conservation land acquisition.*

Increase grassland and open forest restoration

Overall restoration and maintenance of grassland and open forest ecosystems in southern B.C. is essential for recovery of Badgers and numerous other species at risk.

- *Complete regional grassland ecosystem restoration plans.*
- *Support organizations involved with grassland and open forest restoration.*

Performance measures

1. Regional grassland restoration plans drafted and (where possible) implemented.

Objective 2: Increase Badger survivorship and recruitment

Increase the likelihood of Badgers safely crossing roads

Decreasing Badger road-kill rates will be difficult as traffic volumes and road densities are expected to increase. Badgers have large home ranges, move widely throughout them, and will burrow in roadside habitats during the peak traffic months of May to August (Hoodicoff and Packham 2006, Weir et al 2004a). Underpasses and drainage concrete roadside barriers (CRBs) that allow Badger egress from busy highways will likely reduce road mortality (Clevenger *et al.* 2001; Cain *et al.* 2003; Dodd *et al.* 2004; B. Ruediger, 2002 pers. comm.) and will likely benefit several species, in addition to Badgers. Although identifying specific "trouble spots" is difficult because of Badgers' large home ranges, underpasses should be installed wherever possible. Installation costs are minimized when planned in advance and combined with road construction. Many of the collisions between vehicles and Badgers occur because drivers are unable to see Badgers (which are low to the ground and dark-coloured) sufficiently in advance to avoid hitting them. Decreasing the speed of vehicles and increasing driver awareness in areas within high-risk zones and during high-risk times of year may give drivers sufficient time to avoid collisions with Badgers that are crossing roads. The recovery team must work closely with B.C. Ministry of Transportation and Infrastructure to develop a strategy to limit the number of road-killed Badgers.

- *Increase the number of crossing structures incorporated into new and existing highway developments (e.g., underpasses, drift fences).*
- *Where CRBs are necessary, make the use of drainage CRBs standard operating procedure to facilitate safe crossing of the road surfaces for animals.*
- *Decrease traffic speeds in areas of high Badger activity.*
- *Investigate the use of wildlife detection systems to alert drivers to wildlife on roads.*
- *Alert drivers to be prepared for Badgers possibly crossing the road surface.*

Performance measures

1. Identified areas of high Badger activity where conflict with traffic will likely to be an issue.
2. Established, with B.C. Ministry of Transportation and Infrastructure, procedures for retrofitting existing corridors with Badger crossing structures and designing and incorporating Badger crossing structures into new construction.
3. Established, with the B.C. Ministry of Transportation and Infrastructure, policy and procedures for using CRBs in high Badger activity areas.
4. Erected signs, with B.C. Ministry Transportation and Infrastructure of warning drivers of Badgers crossing highways at all high Badger-vehicle conflict areas.
5. Identified areas, with B.C. Ministry of Transportation and Infrastructure, where seasonal speed reductions may be important to improving Badger survivorship.

Decrease habitat suitability near roads for Badgers and their prey
The rights-of-way along most major roads are maintained in an early seral (i.e., grass) structural stage, usually through vegetation management. Unfortunately, this increases the habitat suitability of the rights-of-way for many prey species, which may in turn attract Badgers (Meunier *et al*. 1999).

- *Change the vegetation management of rights-of-way on major transportation corridors to make them less attractive to Badger prey and other wildlife.*

Performance measures
1. Worked with B.C. Ministry of Transportation and Infrastructure to reduce attractiveness of herbaceous vegetative cover and burrowing habitat suitability in all priority areas.

Translocate Badgers where necessary
Other approaches notwithstanding, the recovery team acknowledges that there may be instances when augmentation or local reintroduction may be required (e.g., Kinley and Newhouse 2008). Augmentation is preferable to reintroduction (Griffiths *et al.* 1989), especially near a species' range periphery and for carnivores generally (Wolf *et al.* 1996). Proposed translocations are subject to provincial government translocation policy and wildlife permitting procedures. A translocation methodology has been developed that lists specific criteria that should be met before translocation becomes necessary. This has been distributed to conservation officers around the province to assist with managing badgers in human/wildlife conflict situations.

- *Translocate, where appropriate, Badgers from genetically similar and nearby populations into vacant or critically low-density high-quality habitat.*
- *Establish translocation and population augmentation programs where vacant or low density habitat exists and has little likelihood of being re-occupied by local source populations.*
- *Where possible, translocate Badgers from human/wildlife conflict situations.*

Performance measures
1. Identified high priority translocation areas and initiated translocation programs
2. Established reciprocal Memorandums of Understanding with adjacent jurisdictions to facilitate translocation of Badgers (and others species) for recovery programs.
3. Percent of translocation projects that result in improved badger demographics
4. Badgers are translocated rather then destroyed in human/wildlife conflict situations.

Increase the appreciation of Badgers and their prey
Substantial Badger mortality results from humans misunderstanding the ecological role and behaviour of Badgers (Messick 1987). Public education that increases awareness and appreciation for Badgers helps reduce this mortality source. "Elimination" of extermination may not be achievable (and is likely not measurable), but it nevertheless remains the recovery team's target.

- *Increase the understanding about the benefits of Badgers for healthy grassland ecosystems among landowners and land managers.*

- *Dispel the myth about frequent livestock injury resulting from Badger burrows.*
- *Increase understanding about the ecology and behaviour of Badgers among landowners.*
- *Eliminate extermination and poisoning of Badgers.*

Performance measures

1. Provided alternatives to landowners seeking to destroy problem Badgers or Badger prey.
2. Completed and implemented a communications and outreach plan.
3. Achieved zero mortality of Badgers due to persecution by landowners.

Increase protection of Badgers

Legal protection could apply to Badgers under the *B.C. Wildlife Act* and *Wildlife Amendment Act, 2004* if the species is listed under this legislation, a designation distinct from its current Red-listed status assigned by the provincial Conservation Data Centre. Red-listed species are under consideration for legal designation as threatened or endangered under the *B.C. Wildlife Act*. Badger is a candidate for listing under the *B.C. Wildlife Amendment Act, 2004*. Once enabled by regulation, it will provide automatic protection for listed species.

Although potentially useful, legislation is the least desired option to protect Badgers and their prey. Management of other endangered species legislatively has been controversial (e.g., Wolf management in the United States) and may diminish the cooperation established to date with many landowners. Having a legal protection option is desirable but must be applied carefully and must support stewardship approaches laid out in this document.

- *List Badgers under the* B.C. Wildlife Amendment Act, 2004.

Performance measures

1. Listed Badger under *B.C. Wildlife Amendment Act, 2004.*

Objective 3: Maintain or increase genetic variability within the population

Facilitate increased movement among Badger populations

Maintaining metapopulation linkages will be achieved, in part, by meeting Objective 1, ensuring habitat is maintained across the landscape; and Objective 2, increasing Badger survivorship and recruitment. Achieving these objectives will help ensure that movement among Badger populations is sufficient to maintain genetic variability across the subspecies' Canadian distribution.

Species are more likely to persist if local populations are maintained rather than recolonizing local extinctions (Etienne and Heesterbeek 2001). Ensuring that vacated habitats are recolonized is essential to maintain overall population viability. Fahrig and Merriam (1994) state that probability of recolonization depends on three factors: (1) the spatial relationship of the habitat through which individuals must move to disperse, (2) dispersal characteristics of the species, and (3) temporal changes in the landscape structure. As wide-ranging carnivores, Badgers likely have relatively poor recolonization abilities because, although they can travel long distances during dispersal, habitat loss and alienation and high mortality risk associated with encountering human developments has likely diminished the permeability of the landscape.

- *Increase permeability of landscape for dispersing Badgers.*

Performance measures
1. No populations of Badgers are extirpated.
2. Confirmed movements of individuals among populations via monitoring.

Work with adjacent U.S. states to ensure robust potential source populations
Work with appropriate agencies in states bordering B.C. (Montana, Idaho, and Washington) to achieve effective management of their Badger populations (e.g., closing or restricting hunting and trapping seasons on Badgers in neighbouring counties).

- *Increase knowledge among U.S. biologists regarding the importance of U.S. Badger populations to conservation in B.C.*

Performance measure
1. Established reciprocal Memorandums of Understanding with adjacent jurisdictions to facilitate conservative management of Badger populations adjacent to B.C.

Objective 4: Improve the public's knowledge and awareness of Badgers and increase stewardship of Badgers and Badger habitat

Practical and effective communications are an essential component of conservation work (Jacobson 1999). To date, much success has been realized in raising public awareness and appreciation of Badgers. Many objectives and approaches listed above rely on effective communications and outreach with various target audiences. Refinement of the logic model and a clear overall communications strategy are keys to focusing the substantial efforts required of this and other objectives.

Refine the Badger logic model
Complete and implement a comprehensive communications and outreach plan

Performance measures
1. Refined logic model.
2. Completed and implemented communications and outreach plan.
3. Coordinated communications and outreach with the Grasslands Action Plan (see "Grassland Action Plan" section).

Objective 5: Address key knowledge gaps that limit recovery implementation
Much remains unknown about Badger ecology and the effects of management actions on Badgers. A full description of research questions, needs, and actions underway or completed is in Appendix 2. Some of the higher priority needs include research on mitigating road mortality, describing relationships between range condition and small mammal prey, inventory of un-surveyed habitats, and investigation of Badger use of forested habitats.

Identify and prioritize science and data needs required to support Badger recovery

Engage universities, private consultants, and funding agencies to initiate priority research and monitoring projects

Performance measures

1. Published three peer-reviewed publications on Badger ecology and management in B.C.
2. Presented results of Badger research at five major conferences on ecology and wildlife management.
3. Established new research programs to address remaining priority needs.

Critical Habitat

Identification of the species' critical habitat

Critical habitat as defined under the *Species at Risk Act* has not been proposed for Badgers in B.C. More work is required to identify specific locations or habitat features that are critical to the recovery of Badgers in B.C. Critical habitat for Badgers will be identified in the action plan(s) as appropriate.

The approach to identifying critical habitat for Badgers will be to identify the requirements for maintaining at least 400 adults across their provincial range, as outlined by the 5-year recovery goal in this strategy. Habitat mapping (e.g., Apps *et al.* 2002) will be used to assess the availability of habitat across a variety of land use statuses, including provincial Crown lands and federal lands (Canadian Wildlife Service lands, National Parks, etc.).

Habitat needs of Badgers in B.C. are described previously. Badger habitat use appears to be based primarily on soil features and prey availability (Apps *et al.* 2002; Weir *et al.* 2003).

Substantial research to describe habitat relationships (Apps *et al.* 2002; Hoodicoff 2003; Weir *et al.* 2003; Hoodicoff and Packham 2006) has been conducted to date. While knowledge of those associations has increased, density estimates cannot be applied to habitat suitability rankings with any confidence. Home range size of individual Badgers varies from less than 10 to more than 300 km^2 and other factors complicate our ability to confidently predict Badger density throughout the province.

A substantial knowledge gap hindering the identification of critical habitat is the importance of non-traditional habitats used by Badgers in B.C. These include mid- to high-elevation forests (usually regenerating cutblocks or wildfires within a closed canopy forest mosaic), occasionally closed forest stands at all elevations, subalpine parklands, and alpine meadows. How these habitat types interact with traditional Badger habitats — grasslands and open forests — to contribute to critical habitat is unknown.

Schedule of studies to identify critical habitat

The schedule of anticipated work necessary to identify critical habitat is identified in Table 9.

Table 9. Anticipated work necessary to identify critical habitat for Badger (*jeffersonii* subspecies) in B.C.

Work	Targeted completion
Complete Conservation Assessment	2008
Complete description of critical habitat attributes	2008
Complete inventory of occupied range and habitats	2010
Regional priorities are Boundary, Nicola, West Kootenay, and Similkameen	
Identify suitable unoccupied habitat	2010
Determine amount of habitat required to meet population and distribution objectives	2011
Identify critical habitat in action plan(s)	2012

Existing and Recommended Approaches to Habitat Protection

Some Badger habitat is currently protected from destruction in the following land designations: federal parks and protected areas, provincial parks and protected areas, regional parks, and NGO conservation lands.

The Badger is identified in the category of species at risk in an order made under the Government Actions Regulation of the *Forest and Range Practices Act* – this category represents species that may be affected by forest or range management on Crown land in B.C. Relevant information about species biology and recommended management measures are included in B.C.'s "Identified Wildlife Management Strategy" (Province of BC 2004). The *B.C. Land Act* can also protect Badger habitat. Some Badger habitat has already been protected or enhanced through land use designations, establishment of WHAs under the *Forest and Range Practices Act*, and incorporation of Badger habitat needs into strategic and operational land use planning. Options under other provincial legislation and regulations (e.g., *Pesticide Control Act* Regulations, Community Charter) need to be explored.

Future habitat protection will be accomplished through voluntary stewardship agreements, conservation covenants, eco-gifts or sale of private land by willing landowners, and continued application of land use designations and management on provincial and federal Crown lands and protected areas.

Effects on Other Species

Badger recovery will likely affect other species that rely on grassland and open forest habitats. Most effects are anticipated to be positive. Work to ensure continuing prey populations, particularly Columbian Ground Squirrels, will directly benefit other predators, especially diurnal raptors. Loss of top predators from fragmented ecosystems can trigger trophic cascades that profoundly alter those ecosystems (Crooks and Soulé 1999). Thus other species and their habitat are likely to benefit from recovery actions targeted at Badgers. See "Ecological Role" section for more details on possible effects on other species.

Socioeconomic Considerations

Direct use of Badgers in B.C. is low, in part because they are protected from commercial trapping and because Badger fur is not in demand. There is also little demand for Badger fur from other jurisdictions where few, if any, restrictions are placed on their harvest. However, recovery of Badgers in B.C. will positively affect several land users (Table 10), so indirect use and non-use values of the species may be significant, yet difficult to monetize (Table 10).

Table 10. Summary of potential socioeconomic benefits and costs to various sectors potentially affected by Badger recovery in B.C.

Industry/sector	Location	Potential Benefit/cost	Effect[1]
Ranching/rural land-owners	Widespread primarily valley bottom	Improved burrowing rodent control	++
		Potential for equipment/livestock damage	–
		Increased appreciation of wildlife, habitat, and species at risk	+
Golf courses	Widespread primarily valley bottom	Rodent control reduced ("organic"; fewer pesticides)	++
		Increased development costs to accommodate Badger habitat	– –[2]
		Improved public relations	+
		Increased digging near fairways	–
Forestry	Widespread primarily mid-elevations and valley bottom	Relaxed free-to-grow requirements	++
		Reduced replanting requirements	++
		Increased management responsibility for species at risk	–
Highway planning	Widespread	Increased costs for reducing hazards to wildlife	– –[2]
Urban planning/housing and resort development	Localized primarily valley bottom	Increased costs to accommodate Badger habitat	– –[2]

1 For "Effect" column, one "+" or "–" indicates minor economic benefit or cost, respectively; two symbols indicate greater benefit or cost.

2 Development costs are primarily upfront and "one time only," whereas other benefits/costs may be ongoing.

Ranchers may be positively affected by increased Badger populations because they help control burrowing rodents that cause considerable damage to livestock and farm machinery (Weir *et al.* 2004a). Golf course operators will also benefit from increased control of ground squirrels and Yellow-bellied Marmots on their courses. Forest companies, through their day-to-day silviculture operations, can create Badger habitat in forested areas. For forest resource companies, Badger recovery could involve relaxation or elimination of reforestation standards for specific cutblocks that support colonies of ground squirrels or were once grassland habitats. This would reduce silviculture costs.

However, some land managers may perceive Badgers as a threat to their safety and operations. In the past, Badgers have been viewed as a nuisance to ranchers. Fear of livestock injuring themselves in Badger burrows is commonplace and ranchers have expressed concern about dirt mounds around burrow entrances causing damage to harvest machinery. However, Weir *et al.* (2004a) showed that livestock injury or damage to machinery is exceptionally rare and costs associated with this type of damage are negligible. Additionally, some golf course superintendents consider Badgers a threat to public safety and a nuisance. However, once they

learn about the pest control capabilities, burrowing characteristics (i.e., Badgers do not burrow into greens), and low public liability, many superintendents become supportive of maintaining Badgers near their operations (R. Packham and N. Newhouse, 2004 pers. comm.). Negative perceptions can likely be changed with increased extension and public outreach programs.

Several potential socioeconomic costs are associated with Badger recovery. Although there are currently no regulations requiring private land developers to consider species at risk, recovery of Badger populations will not be effective with continued high rates of habitat loss to this activity. For example, conversion of a grassland area into a housing development that does not retain green space will constitute complete habitat loss. Setting aside portions of the area as undeveloped green space will retain at least some habitat value for Badgers. If recovery is to be effective, developers may face diminished economic returns on land development, compared with conversion of land to a completely modified state. Badger recovery may affect both urban and agricultural land development in this manner.

Recovering Badger populations in B.C. will require mitigating the effects of road and railway mortality. Retrofitting existing highways with effective underpasses and drift fencing, making concrete roadside barriers more permeable to Badgers, and including more underpasses in future highways will likely be costly. However, such work will benefit several species, including Badgers.

Recommended Approach for Recovery Implementation

Grassland Action Plan

While a single-species approach to recovery will be required to address specific concerns related to Badgers, a grassland/open forest ecosystem approach to management of species at risk is strongly recommended. A Grassland Action Plan (Leech *et al.* [compilers] 2006) has been initiated to coordinate implementation of strategies for various species throughout the B.C. Southern Interior. To date, the process has drafted a logic model to coordinate future planning and recovery action items.

The *jeffersonii* Badger Recovery Team endorses this approach and will work within it to achieve objectives common among various species.

Recovery Implementation Groups

The Grassland Action Plan notwithstanding, conservation issues specific to Badgers exist and must be addressed at provincial and regional levels. Recovery implementation groups (RIGs) are an effective means to work on specific projects or programs within the overall efforts of the recovery team. We propose to establish geographic-based RIGs that will build on regional research and conservation efforts. An education and communication RIG and a science RIG already exist. RIGs will implement components of the action plans pertinent to their geographic or topic area.

To date, individual projects have initiated substantial and successful programs for public education and communication about Badgers' need for conservation. The recovery team will continue to build on these successes and achievements. While geographic RIGs are anticipated to

continue local education efforts, a separate RIG will guide overall communication of Badger conservation and research across B.C. This will avoid duplication of effort and funding, ensuring more money is available for each RIG to conduct its research and management programs. It will also ensure that consistent and updated messaging is communicated to specific stakeholder groups and individuals as well as provide key contact information. All Badger research and conservation efforts in B.C. are available at <www.badgers.bc.ca>. The science RIG has identified knowledge gaps and priorities to guide research required to recover badgers. This RIG is responsible for completing a cohesive strategy for conservation research, including targeting and coordinating funding applications.

Statement on Action Plans

Action planning for the recovery strategy will address the following components:

1. Science – Completed
2. Habitat protection & ecosystem restoration 2009
3. Communication & outreach 2009
4. Inventory 2009
5. Road mortality 2009
6. Population augmentation & translocation 2010
7. Critical habitat 2012

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APPENDIX 1. Research Activities Complete or Ongoing

East Kootenay Badger Project

- Research activities are complete, but collection of sightings data and other conservation activities are ongoing.

The East Kootenay Badger Project, a long-term research and conservation project, has been underway since 1996. The general ecology of Badgers was described (Newhouse and Kinley 2004). In addition, a map-based habitat suitability model was prepared (Apps *et al.* 2002). This work provided the impetus to re-assess badger population status across Canada, leading to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status update report (COSEWIC 2000).

From 1996 through 2004, 31 Badgers were radio-tagged and monitored in southeast B.C. to determine the effects of potential management actions on local ecological characteristics. The East Kootenay study area included the southern Kootenay River zone and the northern Upper Columbia zone. The median age at capture was 3 years in the Kootenay and 3.5 years in the Upper Columbia. Mortality causes among residents included unknown (4), roadkill (4), probable or possible predation (3), train kill (1), probable starvation (1; a kit), and probable old age (1). For the Kootenay River and Upper Columbia zones combined, annual home ranges of resident adults averaged 3 to 150 times larger than reported from previous studies in the United States, with means of 17, 24, or 34 km² for females, and 67, 110, or 315 km² for males, based on the 95% fixed kernel, 95% adaptive kernel, and 100% minimum convex polygon methods, respectively. Minimum documented juvenile dispersals were up to 41 km.

Space-use and demography varied along a north–south gradient with southern animals having higher reproductive output, lower mortality, and apparently smaller home ranges. Population projections from the Kootenay River zone suggested population growth of 20% annually and female home ranges there were smaller than recorded in several studies in the United States. In contrast, projections from the Columbia River zone indicated rapid population decline (annual adult survivorship of about 72% and no recruitment); with the exception of translocated animals, there appear to be essentially no Badgers remaining there. However, this spatial comparison was also a temporal comparison, because monitoring gradually shifted southward during the study. In reality, it appears that changes in ecological conditions corresponding roughly to the period of this study may have played at least as strong a role as intrinsic differences from north to south in determining observed patterns. That is, it appears that the Upper Columbia had experienced events at the beginning of the study that pushed the population down to a point from which it could not recover, rather than currently being unable to support Badgers.

Experimental translocation of Badgers from Montana and follow-up monitoring began in 2002 and has been fairly successful, leading to production of kits by translocated females. Continued monitoring of residents in the south and translocated animals in the north should indicate which of the space-difference versus time-difference scenarios is more likely.

Significant achievements included drafting of a translocation proposal, multi-media coverage of the plight of Badgers, development of signs for private landowners and golf courses (Esken

2001), and provision of map-based information to the Regional District of East Kootenay and the Nature Conservancy of Canada.

Publications
Apps *et al.* 2002
Kinley and Newhouse 2005, 2008
Newhouse and Kinley 2000, 2001, 2002, 2004

Thompson-Okanagan Badger Project
- Complete

Initiated in 1999 and completed in 2004, the Thompson–Okanagan Badger Project collected life history data on Badgers for the purpose of conservation planning. Based near Kamloops, fieldwork concentrated on the North Thompson and South Thompson River valleys. Sightings data were collected intensively for the Thompson, Okanagan, and Boundary regions.
This project examined the distribution and ecology of Badgers in the Thompson and Okanagan regions of B.C. with the broad objective of developing conservation strategies for the species. The project had four specific objectives: (1) to determine where Badgers occur in the region, (2) to increase public awareness and understanding about Badgers and grassland ecology, (3) to collect ecological information about Badgers by conducting a radio-telemetry research study, and (4) to synthesize this information into effective conservation strategies for the species.

The project solicited recent records of Badgers from the general public, industry, and government employees from 1999 to 2003. A total of 566 records of Badgers were collected that helped refine the target areas for implementation of conservation strategies. Despite Badgers being considered primarily a grassland species, 38% of records occurred in forested biogeoclimatic units, followed by 33% in open forest units, and 29% in grassland units. The extent of occurrence of Badgers within the Thompson and Okanagan regions was approximately 41,000 km², although the area of occupancy was likely substantially less, especially in the Okanagan valley. This result is significant because it suggests that the Okanagan was probably the historic connectivity corridor between the Thompson and Cariboo population of Badgers and the Great Basin population.

Between 1999 and 2002, 13 Badgers (11 male, 2 female) were captured, radio-tagged, and monitored. The mean home range size (95% fixed kernel estimate) of adult males was 32.7 km² (SD = 11.6, n = 7), whereas the female with kit that was tagged in 2000 had a summer home range of 15.6 km². Five of the 8 radio-tagged Badgers had a few widely dispersed core areas in which they focused their activities. Badgers moved more during the summer than the winter, up to 14 km in 4 hours; during summer, they tended to move at least 500 m within a day. Transportation corridors were the primary source of mortality for Badgers in the Thompson region; 7 of 13 radio-tagged study animals died on highways or railways and an additional 13 untagged Badgers were killed on roads in the region during the study.

Badgers appeared to make the majority of their habitat decisions on the basis of soil features and prey availability, although the male-biased data may have affected this conclusion. The strongest selection was detected for burrowing and foraging resources at relatively fine spatial scales.

Badgers tended to select patches within ecosystem units that were characterized by silty soils with low coarse fragment contents and high concentrations of prey sign. Conservation of patches and ecosystem units with these features is expected to be important for the continued persistence of Badgers in the Thompson and Okanagan regions.

The project also had a strong public outreach component. A wide variety of forums and media were used to inform both the general public and specific target groups about Badger ecology and conservation in the Thompson and Okanagan regions. A total of 24 targeted presentations, 33 newspaper and 6 television news articles, 3 project information posters, and a Badger web site were developed or released to help with public outreach. Additionally, two series of 1000 brochures about Badgers in the Thompson and Okanagan regions were printed and widely distributed. Due to these efforts, members of the public and ranching industry are more aware of the existence, general ecology, and conservation needs of Badgers in B.C.

Conservation strategies for Badgers in the Thompson and Okanagan regions focused primarily on reducing mortality within the population, providing for foraging and burrowing habitats at various spatial scales, and establishing translocation protocols for Badgers that are at risk of being destroyed by private landowners.

Efforts during 2003–2004 focused on implementation of conservation strategies to various target groups. Following the Badger Recovery Strategy and associated logic model developed by the Badger Recovery Team, this project implemented conservation strategies developed during the Thompson-Okanagan Badger Project. The project was comprised of three components: (1) targeted communication/extension programs aimed at private landowners (e.g., ranchers), large land managers (e.g., Ministry of Water, Land and Air Protection, Ministry of Forests, LRMPs), and the general public, (2) an assessment of population enhancement opportunities, and (3) publication of additional media material (e.g., pamphlets, road signs) to help support Badger conservation in target areas. Accomplishments included extensive liaison with highway contractors to help develop options to reduce roadkill of Badgers; production of an information brochure targeted at the general public; media interviews; field visits with forest companies; signage at a golf course in the South Okanagan; public speaking engagements with various conservation organizations; distribution of the conservation strategies to a wide audience of government, industry, First Nations, and conservation organizations; and contributions to better land management through various industry organizations. Unfortunately, the project did not receive funding during 2004–2005 to continue implementation of these conservation strategies in the Thompson and Okanagan regions.

Publications
Hoodicoff 2003, 2004
Weir and Davis 2004
Weir *et al.* 2003
Weir *et al.* 2004b

CRB-Highway Mitigation Trial
- Complete

Traffic-related deaths have been shown to be a significant, if not the most important, source of mortality for Badgers in the Kamloops region. Concrete road barriers (CRB) may be a significant factor contributing to Badger highway mortality because they create a substantial obstacle to Badgers that attempt to cross roads and exit the road surface. This project focused on replacing segments of solid concrete road barriers with barriers that are permeable to Badgers (i.e., CRB with drainage gaps 1 m long by 0.25 m high in the base). Such barriers allow Badgers to escape the highway surface in high traffic areas.

Three priority areas along the Trans-Canada highway near Kamloops were identified for barrier replacement. The barrier replacement converted a 2080-m stretch of continuous solid CRB into 7 sections of 226, 212, 215, 197, 204, 504, and 538 m, respectively; a 750-m section (which had 2 Badger mortalities on it) into 5 sections of 150 m each; and a 450-m section into 2 sections of 150 and 300 m.

The areas with replaced CRB and existing alternative routes under the roadway (2 water and 2 cattle underpasses) were monitored for use by wildlife using sooted track plates and remote-sensing cameras. The project had limited funding for monitoring. No tracks were documented at any of the CRB sites that were monitored, but substantial use of the underpasses was detected.

Results of this work were shared with road maintenance contractors and B.C. Ministry of Transportation and Infrastructure staff to help identify other areas where barrier replacement could occur as part of ongoing CRB maintenance.

Publication
Weir and Davis 2004

Assessment of Damage to Agricultural Operations Caused by Burrows

- Complete

Habitats used by Badgers in B.C. overlap with many agricultural operations, particularly cattle ranches, horse farms, and hay farms. Badgers are often cited as sources of damage to livestock and agricultural machinery. To document the actual frequency and extent of this damage, a telephone survey was conducted of 131 randomly selected cattle ranchers within the range of Badgers in B.C. One-third of ranchers surveyed reported having Badgers on their ranches within the previous 5 years. The occurrence of other burrowing animals was also recorded: Columbian Ground Squirrel occurrence was reported on 64% of surveyed ranches, Pocket Gophers on 59%, and Yellow-bellied Marmots on 56%.

Of the ranchers who reported Badgers, 66% felt the badgers were either beneficial or had no effect on their agricultural operations, 21% felt they were detrimental, and the rest (13%) had no opinion. Although damage to farm machinery by other burrowing animals was frequently reported, Badger burrows were not conclusively linked to any of the damage occurrences. Only one of 131 respondents noted injury to livestock as a result of animal burrows.

A separate telephone survey was conducted of large animal and mixed-practice veterinarians in B.C., Alberta, and Saskatchewan to solicit rates of occurrence of Badger injury to livestock. Of

the 95 veterinarians surveyed, 11 (12%) reported treating animals injured in Badger burrows within the past 5 years. Only 1 of 27 (4%) veterinarians from B.C. reported encountering a livestock injury due to Badger burrows.

Publication
Weir *et al.* 2004a

Ecology of Badger Prey in British Columbia

- In progress

The availability and abundance of prey have been identified as primary factors limiting Badger populations, but there is a lack of knowledge about the ecology of these prey species in B.C. This report synthesized information on Badger prey that will assist in "ensuring adequate prey for Badgers." This report synthesized existing information on Badger prey ecology and its influence on Badger distribution, abundance, productivity, and survival. The ecology of six main prey species for Badgers in B.C. was reviewed: the Columbian Ground Squirrel, the Yellow-bellied Marmot, the Northern Pocket Gopher, the Muskrat, the Red-backed Vole, and the Meadow Vole. Prey distribution affects the range of Badgers and especially their use of non-grassland habitats. Survival of Badgers may be directly linked to prey availability. Decreased prey availability may lead to larger home range sizes, longer distance movements, and increased risk of mortality, especially on roads. Large home range sizes also may lead to lower female productivity by restricting breeding, and ultimately limiting the abundance of Badgers. Future research should identify important prey species for Badgers locally and the influence these have on regulating populations. The effects of disturbance on prey abundance and its role on the use of non-grassland habitats by Badgers should also be explored. Finally, management techniques that promote habitat for prey were encouraged.

Publications
Hoodicoff 2004

Cariboo Badger Project

- In progress

Badgers were previously thought to exist at low densities in the Cariboo because it is the northern and western limit of their range. The recent abundance of Badger sightings in this region indicates that there may be more Badgers there than previously thought. The objectives of this project are to: (1) determine local distribution and relative abundance of Badgers in the region; (2) locate and describe suitable burrowing habitat; (3) identify key prey species; and (4) establish wildlife habitat areas (WHAs) that will protect current burrow sites, and develop best management practices (BMPs) that will maintain and enhance range condition for prey.
Since 2003, Badger sightings reported by the public and made by researchers during this project (n = 86), as well as aerial surveys and ground searches for burrows (n = 589) indicate that Badgers are widely distributed across the region. Badger hair was collected and DNA fingerprinting used to identify 37 Badgers (21 males, 14 females) from 448 hair samples at 188 different burrows. Results from this pilot study suggest that DNA fingerprinting is a viable and cost-efficient option for monitoring the population over a large area. Badgers burrowed

predominantly on grassland slopes adjacent to wetlands in deep aeolian or lacustrine soil deposits. Remains of food items collected at burrows suggested that Badgers were eating a broad range of taxa including mammals, birds, amphibians, fish, and arthropods. The most common species were Snowshoe Hare, Marmot, Muskrat, Columbian Ground Squirrel, and Red Squirrel. Murids also were commonly found in the samples. This information indicates that there is a viable population of Badgers and high quality habitat in the Cariboo region. With further monitoring, the project may be able to accurately estimate the number of Badgers alive expand the ecological knowledge of this species.

Current work includes detailed ecological studies of Cariboo Badgers via radio telemetry. Researchers are identifying locations where Badgers cross highways in an attempt to mitigate road-related mortality. Research is also focused on determining the extent of Badger use of forested ecosystems.

Publications
Hoodicoff and Packham 2006
Packham and Hoodicoff 2004a, 2004b

Badger Conservation Assessment
- In progress

A conservation assessment is a process by which spatial and temporal factors that affect the probability of population persistence for a particular species are evaluated and projected forward in time. The broad objective of this conservation assessment is to develop a spatially explicit prediction of the effects of landscape change on Badger populations. Using landscape change modeling and population viability analysis, policy options most likely to contribute to population persistence will be recommended.

The conservation assessment will involve a number of steps. The first steps involve identifying and characterizing the components of a Bayesian Belief Network (BBN) that will be used to predict population outcomes based on various management scenarios. The next steps involve modeling landscape outcomes upon which the population responses will be predicted. The final steps involve the application of the BBN and will form the basis of the population viability analysis that will predict population responses to landscape change. A final report detailing the methods, assumptions, data sources, relationships, modeling process, and Bayesian Belief Network will be produced.

Publications
Weir 2006

APPENDIX 2. Knowledge Gaps

The science recovery implementation group (RIG) has identified the following areas in which additional information is required to effectively recover *jeffersonii* Badger populations.

Diet

Columbian Ground Squirrels appear to be the main component of Badger diets in B.C. However, the degree to which Badgers rely on ground squirrels and what other food items may be necessary or included in Badger diet is unknown. Badgers are known to persist in areas where ground squirrels are absent; here they are believed to be focusing on microtine rodents as well as amphibians and reptiles (Packham and Hoodicoff 2004). Also, juvenile Badgers may rely more on alternative, more easily captured prey such as arthropods.

Questions:

- How does diet affect spatial ecology?
- How does diet change with prey availability?
- How does diet change with habitat?
- What are dietary requirements of juvenile age classes?
- Winter diet –do Badgers depend on hibernating ground squirrels, or are other foods available and used? How important is food caching (e.g., Michener 2000)?

Needs:

Intensive prey/diet survey. Increased sample sizes are the highest priority overall — this may be most important in the Cariboo region where Badgers may forage more in forested habitats and little information exists.

- Region-, season-, sex-, and age-related monitoring of food habits.
- Scat sampling protocol to ensure the provenance of samples.
- Technological solution to collection of samples from burrows through non-destructive techniques. Development of robotic technologies may be an option.

Actions underway or completed:

- Revisit existing samples using new key and synthesize findings
- Continue to collect stomach and scat samples opportunistically
- Developing sampling methodology
- Bone analyses of Cariboo Badger scat samples

Prey Ecology

Badger research in B.C. has suggested that proximity to ground squirrel colonies is a strong predictor of habitat suitability for Badgers. The substantial body of literature on Columbian Ground Squirrel ecology (e.g., Bennett 1999; Dobson *et al.* 1999; Dobson and Oli 2001; Neuhaus and Pelletier 2001) may not all be directly pertinent to Badger ecology or B.C. A recent review of the ecology of six potential prey species of Badgers (Columbian Ground Squirrels, Yellow-bellied Marmots, Northern Pocket Gophers, Muskrats, Red-backed Voles, and Meadow Voles) examined the role of habitat and habitat alteration on Badger prey (Hoodicoff 2004) and has helped provide information to answer the questions below.

Questions:
- How do important Badger prey respond to land management activities, particularly grazing, cultivation and seeding, and grassland restoration?
- Describe basic ecological habitat relationships for major prey species. How do these relate to prey and Badger distribution and abundance?
- Describe population dynamics and demography of prey, particularly regarding cycles and colony establishment/abandonment. What role does disease (in prey species) play in this?
- What is the role of prey in Badger use of non-traditional habitats (e.g., forested and alpine)?

Needs:
- Conduct baseline descriptive ecological studies on major prey species (particularly ground squirrels and pocket gophers).
- Examine the effects of grazing and fire on Badger prey in grassland and forested ecosystems (particularly relevant in the Cariboo region).
- Monitor prey responses to restoration.
- Evaluate the value and temporal extent of recent cutblocks as habitat for Ground Squirrels.
- Collect autecological information for Northern Pocket Gopher.

Actions underway or completed:
- Prey ecology synthesis completed
- Grassland project to examine the effects of grazing on small mammal populations initiated

Mortality Factors

Roadkill accounts for a significant amount of Badger mortality (Messick 1987; Newhouse and Kinley 2004; Weir *et al.* 2004b). There is a clear need to understand the underlying causes of these road mortalities to develop effective mitigation measures that lessen the impacts.

Questions:
- Are roadways attractive to Badgers?
- What mitigation measures can reduce road mortality?
- Are specific sex- and age-classes more susceptible to roadkill?

Needs:
- Monitor existing highway CRB replacement barriers is a priority to determine whether Badgers (and other species) will use them.
- Produce a retrospective analysis of features (physical, topographical, biological, traffic, etc.) associated with known mortalities to determine whether some features increase mortality risk.
- Experimentally evaluate drift fences to determine whether these can effectively route Badgers (and other animals) through safe crossings (e.g., culverts).
- If possible, analyze toxicity of existing Badger tissue (in storage) to assess whether secondary poisoning (through consumption of poisoned pocket gophers, ground squirrels) is an issue for Badgers.
- Document injury of livestock in Badger holes.

Actions underway or completed:
- Survey of Badger burrow damage to machinery and livestock completed (Weir *et al.* 2004a)
- Badger highway mortality mitigation trial completed (Weir and Davis 2004)
- Badger highway crossing project initiated

Distribution and Abundance
Efforts to document the distribution and abundance of Badgers in B.C. have focused on the East Kootenay, Thompson, and Cariboo areas. However, Badger distribution and abundance are poorly understood in other regions of B.C. The Okanagan may have represented some of the best *jeffersonii* Badger habitat in Canada, but has also likely seen the most habitat loss due to urbanization, cultivation, and viniculture. Additionally, very little is known about Badger distribution and abundance through the Nicola, Boundary, and West Kootenay regions.

Questions:
- Where are Badgers on a provincial scale and in what relative abundances?
- Are Badgers occupying alpine habitat throughout their range in B.C.?

Needs:
- Establish regional reference sites to monitor distribution and abundance.
- Identify focus areas for sightings (and possibly burrow) surveys to test movement hypotheses.
- Develop a Badger identification card that the public can use.
- Establish sighting databases, possibly one that could be used as a long-term index.
- Collect distribution and abundance data from three priority areas that are currently receiving little attention — Nicola, Similkameen, and Boundary. A hair snagging protocol may need to be developed to facilitate this.

Actions underway or completed:
- Regional Badger databases are being maintained
- Badger web site (<www.badgers.bc.ca>) provides information to help members of the public identify Badgers and their burrows
- Inventory projected initiated in Nicola region

Inventory Methodology and Development
Estimating populations of Badgers is currently an extremely expensive and time-consuming process that involves invasive capture techniques. Developing non-invasive inventory techniques that reliably and inexpensively estimate population is important to measure the success of other recovery efforts in increasing Badger numbers across their distribution.

Questions:
- Can active burrows be used as an effective presence/absence indicator or population index?
- How can we count Badgers? Non-invasive options include hair snags for DNA mark/recapture techniques (Foran *et al.* 1997; Mowat and Paetkau 2002; Frantz *et al.* 2004; Packham and Hoodicoff 2004) and aerial surveys for active digging (Packham and Hoodicoff 2004).

Needs:
- Independent trials of various indices within an intensively monitored population (e.g., maintenance of core home range, number of family groups reported, fresh digging).
- Develop techniques for DNA sample collection.
- Independent trials of indices.
- Develop population estimation and monitoring protocols. These should build upon the genetic capture/recapture work currently underway in the Cariboo and require a retrospective analysis of latency to detection. The eventual product should be used to revise the Resource Information Standards Committee (RISC) inventory standards for Badgers.

Actions underway or completed:
- A hair snagging program was initiated in 2003 in the Cariboo region (Packham and Hoodicoff 2004) with promising results. This project is continuing.
- Surveys for Badger burrows as part of several Interagency Recovery Fund projects on federal land (e.g., Spallumcheen Indian Band, Canoe Creek Indian Band, Dominion Coal Blocks)
- Aerial burrow surveys in the Cariboo region (Packham and Hoodicoff 2004)
- Revised Badger inventory standards completed (Ministry of Environment 2007)

Population Ecology, Meta-population Structure, and Genetics

The Boundary and West Kootenay regions in particular may represent an important linkage between the two main Badger populations in the province. More knowledge is required regarding movement of Badgers between populations. DNA samples are currently collected from all captured and road-killed Badgers, but more work is required to understand the genetic (i.e., historical) relationships among B.C.'s Badger populations and those immediately to the south in the United States.

Questions:
- Are Badger movements primarily north–south along valley bottom lines and are Badger interacting with populations in the United States?
- To what degree do Badger populations within B.C. interact via east–west (inter-valley) movements?
- How isolated are Badgers in the East Kootenay from the *T. taxus taxus* subspecies in Alberta? Does the Crowsnest Pass area facilitate movements between these populations, one at risk (*T. taxus jeffersonii*) and the other not (*T. taxus taxus*) (COSEWIC 2000)?
- How much genetic structuring exists within the Thompson-Okanagan-Cariboo population?
- What role does Badger density play in determining home range size?
- Does scarcity of females limit some components of the Badger meta-population? In the Thompson region, few females have been captured. Is this due to low female numbers or "trap-shy" behaviour? What are their survival rates and reproductive rates?
- Are male densities a limiting factor in pregnancy rates of female Badgers? The nature of the relationship between density of male Badgers and pregnancy rates of females is currently undetermined. Current trends in the Kootenays indicate that this may be an issue in successful recovery.

Needs:
- Further delineate possible population units within Thompson-Okanagan-Cariboo metapopulation.
- Identify potential dispersal corridors (using habitat and topography models) between population units.
- Identify potential movement barriers.
- Conduct mitochondrial DNA analysis of Thompson Badgers to determine minimum number of adult females.
- Investigate population vital rates relative to male and female Badger abundances.

Actions underway or completed:
- An archive of tissue from road-killed Badgers from throughout their range in North America was initiated in 2003. Samples have been collected from 12 jurisdictions, including Washington, Idaho, and Montana. This project is continuing.
- An assessment of gene flow among Badger populations in B.C., Alberta, and Montana showed very little east–west gene flow (Kyle *et al.* 2004)

Habitat Ecology

Badgers are traditionally thought of as grassland predators. Alpine ecosystems are similar in that they also generally lack trees, but they have not traditionally been considered Badger habitat. We do not know to what extent alpine ecosystems play a role in Badger ecology in B.C. Are Badgers transients there in snow-free seasons, or are they year-round residents? As results to date are unclear, more information is required.

Similarly, Badgers use montane forest ecosystems in B.C. (Apps *et al.* 2002; Weir *et al.* 2003). These areas are often characterized as "not sufficiently restocked" early-successional forest stands following logging and/or wildfire disturbance. Like the alpine, the importance of these ecosystems for Badgers is unknown.

A wide variation in habitat use and home range size has been observed. Does this reflect movements to widespread ground squirrel populations or Badgers fulfilling other life history processes? Particular focus should be placed on female reproductive success (as above), dispersal, and mortality factors.

Questions:
- Is there another ecotype of Badgers that uses only alpine habitats?
- Do Badgers use forested habitats extensively anywhere and, if so, what prey do they depend on?
- How can burrowing habitat be effectively characterized?
- How long are cutblocks or old burns valuable habitat to Badgers and how do various silvicultural activities influence this?
- Are natal dens regularly reused?

Needs:
- Study the ecology of Badgers in the Cariboo mixed forest/grassland environments is the highest priority.

- Describe ecological characteristics of burrowing habitat (soil, range condition, aspect, etc.).
- Monitor Badgers in alpine habitats.
- Monitor Badgers in forested habitats.
- Monitor Badgers in forested habitats under various silvicultural regimes including non-harvested.
- Evaluate prey abundance and availability in cutblocks of varying ages.

Actions underway or completed:

- Badger habitat described (Apps *et al.* 2002; Hoodicoff 2003; Weir *et al.* 2003; Packham and Hoodicoff 2004)
- Cariboo Badger ecology project initiated