NATIONAL RECOVERY STRATEGY
for

AMERICAN BADGER, *jeffersonii* SUBSPECIES
(*Taxidea taxus jeffersonii*)

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Recovery Strategy for American Badger, *jeffersonii* subspecies.

Disclaimer

The National Recovery Plan for the American badger (*jeffersonii* subspecies) was prepared by the *jeffersonii* Badger Recovery Team. Consultation with participants and other experts identified actions deemed necessary to protect and recover this subspecies. It is based on scientific principles where possible and expert opinion where data are deficient. This plan does not necessarily represent the official position of the agencies, organizations and individuals involved with the Recovery Team and the drafting of this plan. The goals, objectives and actions identified herein are subject to the priorities and financial constraints of the participating jurisdictions, organizations and individuals. This plan is a living document that should be revised and updated to adapt to new findings and research results.

Acknowledgments

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I. BACKGROUND

Species Information

1. **Scientific Name:** *Taxidea taxus jeffersonii*
2. **Common Name:** American Badger, *jeffersonii* subspecies
3. **Current COSEWIC Status & Year of Designation:** Endangered (2000)
4. **Range in Canada:** Southern Interior of British Columbia
5. **Rationale for Status:** low population size, continued decline and habitat loss.

Current Distribution and Abundance

Global

Canada represents the northern-most limit to the *jeffersonii* badger[1] range. This subspecies occurs south into the USA throughout the Great Basin, west of the Rocky Mountains and north of southwestern deserts (Figure 1). There is no population estimate for the entire *jeffersonii* subspecies of badger. The Global Rank for the entire badger species is G-5, defined as "common, widespread, and abundant, although it may be rare in parts of its range, particularly on the periphery" (Nature Serve 2001). There is no global rank for the *jeffersonii* subspecies.

Canadian

In Canada, *jeffersonii* badgers occur only in British Columbia. Their range extends east of the Coastal and Cascade Mountain ranges in the dry southern interior of B.C. and north to the Cariboo region (Figure 2). Range does not appear to have changed significantly following settlement (Newhouse & Kinley 1999). Current estimates of abundance is less than 200 adults. The British Columbia Conservation Data Centre ranks badgers provincially as S1, defined as "critically imperilled in the sub-nation" (Nature Serve 2001).

Figure 1 Range of the American badger, *Taxidea taxus*, and its four subspecies, in North America (source: Newhouse and Kinley 1999).

Percent of Global Distribution in Canada

Approximately 5% of the subspecies' global distribution is found in Canada, all of which is in British Columbia. The percentage of *jeffersonii* badger individuals residing in Canada is unknown, because there are no population estimates from the United States. The number is likely less than 5% because badger home ranges are

[1] For purposes of this document, all references to 'badger' refers to the subspecies in question: *Taxidea taxus jeffersonii*. All other American badger subspecies will be appropriately referenced.

significantly larger in B.C. (Newhouse and Kinley 1999) and therefore densities are likely to be significantly lower than the subspecies' core range in the U.S.A.'s Great Basin.

Population Trend

No historical data for badger population numbers in British Columbia exist. Population estimates have been lowered over the past 5 years as more reliable data based on research projects replaces previous 'best guesses' from wildlife managers. Newhouse and Kinley (1999) suggested 250-600 individuals in B.C. Since 1996, badgers have been observed to be extirpated from the Upper Columbia Valley of the East Kootenay region (Newhouse and Kinley 2000). Further evidence of a decline includes:

- Low number of female and juvenile captures. Between 1996 and 2000 in the East Kootenays, only 7 of 20 badgers (35.0%) were juveniles, of which 5 were known and targeted (Newhouse and Kinley 2001). Other studies report juvenile capture rates are closer to 50% (Messick and Hornocker 1981; Warner and Ver Steeg 1995). In the Thompson / Okanagan region, 12 of 14 captured badgers were males (Weir and Hoodicoff 2002).
- Relatively older individuals. Average age of 13 adult badgers in the East Kootenay was 4.8 years (Newhouse and Kinley 2001), higher than that reported for badgers in Illinois (<3 years; Warner and Ver Steeg 1995) and Wyoming (4 years; Goodrich 1994). This suggests an ageing population which may not be replacing itself. As older individuals die-off, a reduced number of juveniles will be available to fill vacated home ranges. If this results from low reproductive rates, it may indicate either difficulty in finding mates or be symptomatic of inbreeding (Lande 1988; Simberloff 1988).

Biologically Limiting Factors

Reproductive capacity

Badgers may be prone to factors limiting population recovery of other mustelids such as low reproductive capacity (Weaver et al. 1996; Rahme et al. 1995; Ruggiero et al. 1994). Females can start breeding in their first season, but only 30 to 50% do so (Messick and Hornocker 1981). Males don't mature sexually until over one year in age (Messick 1987) but are not thought to contribute significantly to reproduction until they are more than four years old. Litter sizes vary from 1 to 5 (Lindzey 1982), but tend to be smaller further north. Mean litter size in British Columbia is 1.4 kits per litter (Table 1).

Females are capable of producing a litter annually, but data from B.C. suggest this is rare. In the East Kootenay between 1996 and 2000, five adult females fitted with radio-transmitters were monitored for one to four years, representing twelve possible litters. However, only four litters were observed. Further, contribution to breeding is not even: of these four litters, three came from one female (Newhouse and Kinley 2001).

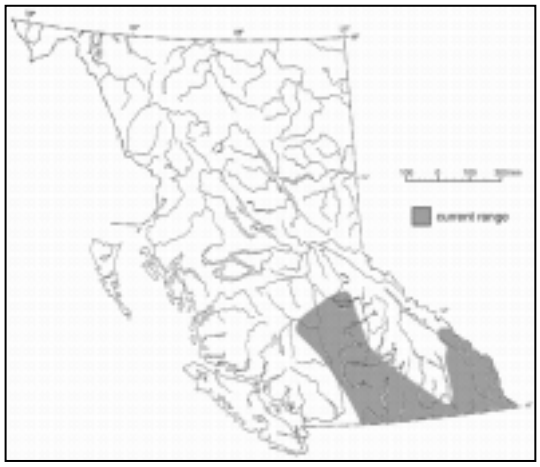

Figure 2 Range of the American badger, *Taxidea taxus*, in British Columbia, in 1998 (source: Newhouse and Kinley 1999).

Reproductive capacity may also be limited by other means. Badgers are believed to be induced ovulators and may require multiple copulations (Minta 1993; Messick and Hornocker 1981). They also exhibit delayed implantation which may be triggered by environmental conditions and prey availability. If breeding opportunities are limited by low densities (therefore reduced encounters) and food sources are unreliable, overall reproductive output at the population level could be limited.

Juvenile survivorship

Recruitment may be further compromised by low juvenile survivorship. Juvenile badgers may be predated by coyotes, bobcats, cougars, ravens and golden eagles (Rahme et al. 1995 and references therein; see page 30 for scientific names). Annual survival rate for juvenile badgers in the East Kootenays between 1996 and 2000 was 27% (n = 7 tagged juveniles). In contrast, annual survival rate for adults over the same period was 72% (n = 20 tagged adults; Newhouse and Kinley 2001). These rates are comparable to other studies (Hoff 1998; Warner and Ver Steeg 1995) and are likely similar elsewhere in B.C. However, they indicate low recruitment of juveniles into the adult population which could limit the ability of badgers to repopulate areas following a decline.

Large home range

Minta (1993) showed that male home range size is limited by the number of females. Where female numbers are high, males need not range far for breeding opportunities. Female home range size is limited by food availability. Badgers in B.C. have exhibited much larger home ranges than conspecifics elsewhere (Weir and Hoodicoff 2002; Weir et al. 2001; Newhouse and Kinley 2000; 1999). Factors contributing to this may include low prey densities (food searching) and low badger densities (mate searching). The increased movement associated with large home ranges may expose individuals to increased mortality risk from highways and predation.

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. This could easily lead to over-estimates of population size (Newhouse and Kinley 2000).

Table 1 Summary of badger litter sizes in British Columbia from radio telemetry studies and sightings databases. For sightings data, all badger groups observed are assumed to be one female with kits (litter size = group size – 1).

Location	mean	n[1]	range	Source
East Kootenay	1.40	10	1-2	Newhouse & Kinley (2002) • radio telemetry: 1996-2001 • sightings: 2001[2]
Thompson / Okanagan / Boundary	1.42	33	1-3	R. Weir (unpublished data) • sightings: 1987-2001

[1] total number of litters observed.
[2] does not include unconfirmed sighting of 5 badgers (assume mother with 4 kits) near Elkford, BC, in 2001.

At northern range limit

Individuals at their range limit tend to be more at risk than core populations. The smaller size and isolation of peripheral populations are thought to have lower genetic diversity than core populations due to genetic drift and isolated populations show greater differentiation (Lesica and Allendorf 1994). Although these factors may have positive influences on species' overall genetic diversity (e.g. novel selection pressures advancing evolution; Fraser 2000), generally the peripheral populations will experience more fluctuation in population 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 (Wolf et al. 1996; Griffith et al. 1989).

Behaviour – susceptible to road kill, human disturbance.

All mustelids are well-known for their fearless behaviour. Adult badgers likely have few natural predators other than humans and stand their ground when faced with a threat. Therefore when faced with novel threats for which they have not evolved adaptive mechanisms, badgers seem to be particularly at risk. Road kill is a major source of mortality. Prey species such as Columbian ground squirrels and yellow-bellied marmots frequent grasses and friable soils characteristic of roadside environments, which may subsequently attract badgers (Weir and Hoodicoff 2002). Their large home ranges also increases the encounter rate with roads and highways.

Threats

There are numerous proximate threats to badger populations throughout British Columbia (Table 2). There is little, if any, empirical evidence to suggest the relative significance of any individual threat in the decline of *jeffersonii* badgers in Canada.

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 is a less dramatic decline in quality (Hunter 1996), often resulting from agricultural development, that reduces habitat availability or quality. Although the overall geographic range of badgers in B.C. may not be significantly reduced, substantial habitat loss and degradation has occurred within this range over the last 50 years in what was likely the best badger habitat in British Columbia – grassland and open forest valley bottoms.

There are many proximate causes of habitat loss and/or degradation:

- highway construction
- urban development, both housing (residential, industrial) and road construction
- agricultural cultivation
- viniculture and orchard development
- forest in-growth and encroachment
- reservoir flooding

Table 2 List of probable continuing and historic threats to badger populations and habitats in British Columbia. These are ranked by relative impact (predominant or contributing), the spatial distribution of the threat (widespread or local), temporal impacts (chronic, episodic or ephemeral), and if the threat has been abated.

Threat	Impact	Spatial	Temporal	Abated?
trapping	predominant	widespread	episodic	yes
persecution	contributing[1]	widespread	chronic	partially
urban development	predominant	widespread	episodic	no
cultivation	contributing	widespread	chronic	no
viniculture & orchards	contributing	local	chronic	no
poor range management	contributing	local	chronic	no
forest in-growth & encroachment	contributing	widespread	chronic	partially
reservoir flooding	contributing[2]	local	chronic	no
highway mortality	predominant	widespread	chronic	no
loss of prey	contributing	widespread	episodic	no
secondary poisoning via prey	contributing	local	ephemeral	partially

[1] Degree of persecution is unknown. Impact is potentially substantial at a local level.
[2] Across all of B.C., reservoir flooding has likely had limited impact on population numbers. However at a local level (e.g. Lake Koocanusa in southern Rocky Mountain Trench), impacts are likely predominant.

Badgers are somewhat tolerant of human activity, which means that many sites are considered degraded habitat rather than lost.

Badger habitat has also been degraded by forest encroachment and in-growth. The exclusion of fire from interior ecosystems throughout much of the 1900s is known to have had a wide range of effects (Keane et al. 2002). Fire suppression throughout much of British Columbia's southern interior has fostered the growth of young forests that were historically cleared by regular low-intensity fires (Table 3; Gayton 2001). Increased forest canopy closure may reduce habitat quality for prey species. Research in British Columbia has shown badgers use forested landscapes (e.g. Weir and Hoodicoff 2002). However, this is limited to where prey populations are plentiful, usually associated with friable soil types (Apps et al. 2002) following logging or wildfire disturbance. Ingrown areas tend to be dense stands of small diameter Douglas-fir and lodgepole pine that support a much reduced biodiversity (Gayton 2001) and probably support reduced prey populations.

Valley bottom habitat has also been flooded in many parts of badger range in B.C. for hydroelectric development. This is particularly true in the southern Rocky Mountain Trench (Lake Koocanusa) where 64 km^2 of grassland and open forest in Canada were lost to reservoir flooding. The entire reservoir above the Libby Dam (completed in 1973 and flooded a year later) removed 187 km^2 of badger habitat in both British Columbia and adjacent Montana (B. Gammer pers. commun.). This area still maintains one of the highest densities of *jeffersonii* badgers in Canada, but has been degraded from its original state.

Reservoirs have also fragmented badger habitat. Badgers are known to cross large rivers, including the South Thompson near Kamloops. However, flooded reservoirs such as Lake Koocanusa, may represent a movement barrier. Habitat fragmentation is likely less of a concern for badgers than total habitat loss (Fahrig 1997). Their wide-ranging movements may help to overcome a fragmented home range where movements are not impeded. However, increased movements also increases mortality risk, especially where roads must be crossed and barriers such as large reservoirs may further isolate already declining populations.

Highway mortality

Highways account for a disproportional amount of mortality for badgers in British Columbia (Weir and Hoodicoff 2002; Newhouse 2001; Weir et al. 2001) and elsewhere (Messick 1987). Badgers in the East Kootenay were found closer to paved roads than expected (Newhouse & Kinley 2000) and 67% of known mortalities in the Thompson/Okanagan were attributed to road-kill (Table 4). Road kill is also of concern to American wildlife managers (B. Ruediger pers. commun.). Lyle Lewis (pers. commun. to B. Ruediger) observed 100 road mortalities within six months on a 65km stretch of highway near Boise, Idaho.

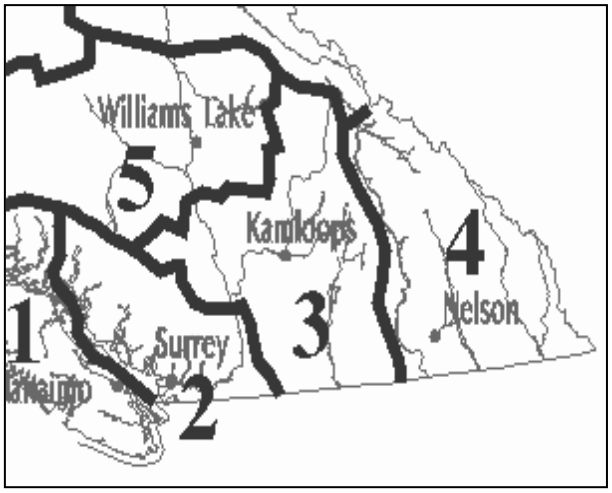

Figure 3 Southern administrative regions for BC Ministry of Water, Land & Air Protection. *jeffersonii* badgers are known from Regions 3, 4 and southeastern part of 5.

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

- Badgers prefer open forest valley bottoms; this is where highways are most often constructed.
- The substrates used to build highways are ideal habitat for ground squirrels and marmots, so badgers are drawn to the highways by the availability of prey.
- Badger behaviour, typical of most mustelids, leaves them vulnerable to road kills.
- Badgers are most active at night, when drivers will have the most difficulty seeing a relatively small, low-to-the-ground animal.

Mitigation is difficult. Large home ranges maintained by badgers means there are few regular road crossing areas where speed reductions may be efficient. Further, there is generally poor compliance with speed restrictions.

Concrete barriers on highways compound the threat to badgers. Weir et al. (2001) cite reports of badgers running along the roadside trying to get around such barriers. An individual was eventually killed on a highway along one continuous 2.5km stretch of concrete barrier.

Grain spills on railways may act as attractants to badger prey, leaving badgers at risk near rail lines. Although railway mortality has been recorded, it occurs at a much lower rate than on highways and considered to be a significantly lower threat.

Table 3 Regional estimates of forest in-growth and encroachment. Regions generally correspond with Figure 3. Source: Kirby and Campbell (1999).

	Kamloops (Region 3)			Kootenay (Region 4)		
	In-Growth 6-15%[1]	In-Growth 16-65%	Encroach.	In-Growth 6-15%	In-Growth 16-65%	Encroach.
total area (ha)	46,712	190,891	18,852	32,082	101,173	30,154

[1] Percent crown closure of forest stand.

Loss of Prey

Badgers in British Columbia 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 (Newhouse and Kinley 2000; Messick 1987). All prey species, ground squirrels in particular, are often the subject of intense extermination programs by landowners. Rodenticide poisons are the most common form of control, usually leaving dead rodents in their burrows underground.

Schedule "B" of the British Columbia Wildlife Act lists species "that may be captured or killed only for the specific purpose of protecting property" (WLAP 2001). Badger prey species included on this list are Columbian ground squirrel, yellow-bellied marmot, northern pocket gopher and all arvicolid rodents (voles). There are also year-round open hunting seasons on private land, with no bag limit, on Columbian ground squirrels in Regions 3, 4 and 5 (Figure 3).

There are two potential negative effects on badgers:

a) direct loss of food resource

Most 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 speculated to be substantial. Reducing prey populations may further limit badger populations and force greater movements to find adequate food resources.

b) poisoning

Badgers may be indirectly affected by scavenging dead rodents killed by poison (Rahme et al. 1995). Rodenticide may be transferable to predators from poisoned animals with subsequent deleterious effects.

Trapping

Research in southern Idaho (where an open trapping season continues; Messick 1997) showed that the overwhelming source of badger mortality is human-caused (Table 4). Human-caused mortality also accounts for the majority of known deaths in British Columbia.

Table 4 Causes of badger mortalities from southern Idaho and British Columbia. For East Kootenay and Thompson / Okanagan locations, percentages are calculated only for the proportion of instrumented badgers. Probability of observing mortality in non-instrumented badgers is strongly biased toward highway road-kill.

Location (Sources)	Cause	N	%
Idaho (Messick 1987)	Killed by local residents	94	59.9
	Road Kill	52	33.1
	Natural / Unknown	11	7.0
East Kootenay (Newhouse & Kinley 2001; Newhouse 2001)	Road / Rail kill	6	40.0
	Natural / Predation / Unknown	9	60.0
	additional known road-kill	12	-
Thompson / Okanagan (Weir et al. 2002)	Road Kill	4	66.7
	Natural / Predation / Unknown	2	33.3
	additional known road-kill	8	-

Commercial harvest of badgers likely contributed to the initial decline of the overall B.C. population. The annual numbers of badgers trapped for four years in the mid-1920s (Figure 4) is greater than the estimated population for the entire province today. Trap returns remained very low after the 1940s. Trapping seasons were closed across the province in 1967 and have remained closed. Private land owners are still able to kill badgers on their property if they are deemed to be causing damage and badgers may occasionally be caught in traps set for other species, such as coyote (Rahme et al. 1995). Provincial regulations require trappers to surrender all by-catch species without an open season and no pelts have been received by the B.C. government in this manner.

Table 5 Trapping seasons and regulations for badgers (*jeffersonii* subspecies) within its American range for states bordering its Canadian range.

State	Season	Restrictions	Source[2]	Official Status
Washington	Nov 14 – Feb 28[1]	None	Harriet Allen	Common
Idaho	Year round	None	Chuck Harris	Common
Montana[3]	Year round	None	Brian Giddings	Common to locally abundant

[1] can be trapped at any time of year if 'causing damage'
[2] individuals are representatives of respective State Fish & Wildlife Departments.
[3] Montana does not differentiate between *Taxidea taxus jeffersonii* subspecies (found west of Rocky Mountains) and *T.t. taxus* subspecies (found east of Rocky Mountains). Most badgers trapped are likely *T. t. taxus*.

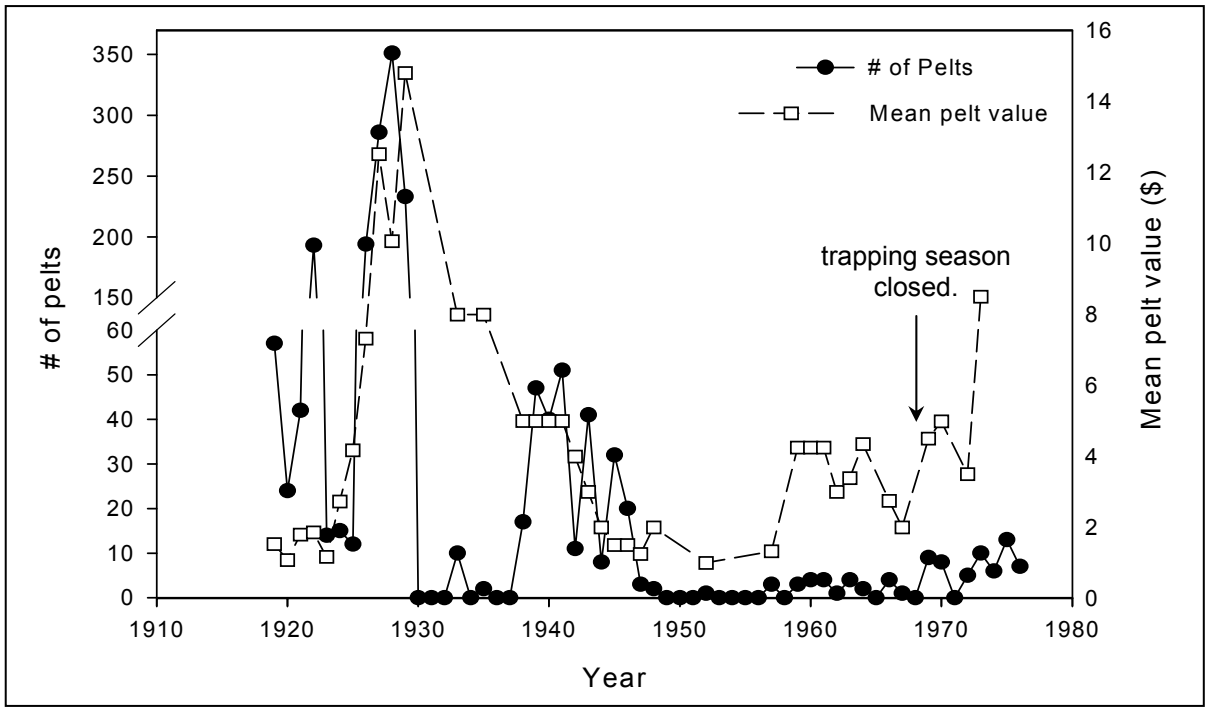

Figure 4 Annual number of badger pelts traded in B.C. and average pelt value, 1919/20 to 1976/77. Trapping season on badgers closed in 1967. Note left axis splits, right axis does not.

Although commercial trapping has been effectively eliminated from British Columbia, adjacent American states have quite liberal regulations on trapping badgers (Table 5). The amount of trans-boundary movements by badgers is unknown, however given the large home ranges documented for badgers in British Columbia, it could be significant. Badger populations in adjacent states likely represent the main source population for *jeffersonii* badgers in Canada. Unrestricted trapping of *jeffersonii* badgers in the USA may have conservation implications for the subspecies in Canada.

Persecution

Persecution is defined here as the legal or illegal killing of badgers in an attempt to exterminate them from private property. This activity remains a threat to badgers. Badgers are known to utilize urban interfaces and are reasonably tolerant of human presence. They readily use roadside berms to excavate burrows and sightings from British Columbia include golf courses, ranches, ginseng farms, mining operations and a ski hill. 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. Unconfirmed reports persist of badgers chasing people, though these are likely untrue (E. Garde pers. commun.).

Extensive persecution in adjacent American states (see Table 4) is also a concern for *jeffersonii* badgers in Canada. Individuals are regularly killed as nuisance animals (J. Williams pers. commun.). Similar to trapping, this added mortality may have conservation implications in Canada through emigration and dispersal of individuals from the USA to Canada.

Ecological Role

The badger is the only fossorial carnivore in the grassland and open forest ecosystems of the southern B.C. interior. Although it is predated by coyotes, wolves, domestic dogs, bobcats, cougars, ravens and large raptors, these instances are likely few and directed largely at juveniles.

Badgers themselves are opportunistic hunters, preying on a variety of animals. Gut analyses from the East Kootenay have revealed Columbian ground squirrels, yellow-bellied marmots, northern pocket gophers, various microtine rodents, birds, insects and fish (Newhouse and Kinley 2000;). Reptiles, amphibians and other invertebrates (e.g. grasshoppers) are also eaten (Messick 1987). The birds and fish are likely rare occurrences, although badgers could be regular nest predators of ground-nesting songbirds. Small mammals, particularly 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 British Columbia, but their role as a prey species is not well understood.

Burrows dug by badgers form important habitat components for other species. Burrowing owls, western rattlesnakes and gopher snakes use badger burrows for nesting sites and thermal cover.

As a wide-ranging carnivore, badgers can be considered an "umbrella species" (Hunter 1996). Many assume that conserving species with large home ranges ensures that adequate habitat for a variety of species dependent on similar habitat types (e.g. Bunnell et al. 1999). Although there is little empirical evidence to support this, it is reasonable to speculate this may be the case for badgers. Noss et al. (1996) cite the Canadian Rocky Mountains as an area suitable for wide-ranging carnivores to act as umbrella species. Relatively low species richness and endemism means that ensuring persistence of a top-level species will likely help protect most other species.

Habitat Requirements

Rahme et al. (1995) list only two known habitat requirements: friable soil for digging and prey to eat. Badger habitat requirements are otherwise very plastic. Both research projects in British Columbia have found badgers in all available biogeoclimatic (ecological) zones – from hot, dry grassland valley bottom to alpine tundra. However, preferences seem to be for non-forested grasslands/fields or open-canopied forests (Apps et al. 2002; Weir et al. 2001).

Soil types preferred by badgers include brunisols, which are typical of the drier, more open forests commonly found at lower elevations in British Columbia. Selected soil types are coarse enough to resist collapse when wet. But overly coarse gravel components (e.g. morainal) often hinder their digging capability (Apps et al. 2002).

As wide-ranging meso-carnivores, badgers require substantial tracts of suitable habitat to maintain viable populations. The three biogeoclimatic zones (Meidinger and Pojar 1991) most preferred by badgers (Bunchgrass, Ponderosa Pine, Interior Douglas-Fir) are among the most poorly represented by protected areas in British Columbia and under the most intense development pressure. Although badgers (and their prey) will utilize other zones, both maintain their highest density in these areas. Commercial logging may be beneficial to badgers by increasing the open, early successional forests preferred by Columbian ground squirrels and other prey. Range practices are likely more important. Especially in areas where Columbian ground squirrels are absent, badgers may rely on prey species (e.g. microtine rodents) that require late seral, highly structured grassland communities.

Maintaining large tracts of relatively undeveloped, non-urbanized land is essential. This land should be uncultivated and non-urbanized. British Columbia's Agricultural Land Reserve (ALR) is designed to maintain land for agricultural purposes and may be useful to maintain non-urbanized badger habitat. However, the ALR also requires habitat to be available for cultivation which is not beneficial to badgers and may actually impede implementing conservation covenants directed toward maintaining natural grassland communities (D. Smith pers. commun.) Nonetheless, any proposed changes to the ALR must be evaluated with respect to their potential impacts on badgers in British Columbia.

Ensuring effective conservation of these habitat types and a reliable food source will help ensure that badgers persist throughout their range in British Columbia. Protection need not be through traditional means of establishing parks. Maintaining large areas of undeveloped land, or grazing pasture, combined with reliable prey populations should be sufficient. Where livestock grazing is permitted, sufficient natural grassland structure and cover should be maintained to allow prey populations to thrive in grassland areas.

Continuing to divide grasslands and open forests into small acreages or urban development will continue to fragment badger habitat and extant populations. Well managed ranches and large land parcels, therefore, are key to maintaining badger habitat in British Columbia.

Socio-economic Considerations

There is little direct economic value of badgers in B.C.; they are protected from commercial trapping. There is little demand for badger fur from other jurisdictions where few if any restrictions are placed on their harvest. More concern comes from conflicts with land owners. In the past, badgers have been viewed as a nuisance to ranchers. Fears of livestock injuring themselves in badger burrows is commonplace, though likely misguided. No known records

exist of such injuries. Dirt berms around burrow entrances can cause damage to cultivation and harvest machinery.

More recently, landowners have appreciated the advantages of badgers in controlling rodent populations (Figure 5). Similarly, golf courses are being approached to reduce or eliminate their applications of rodenticide. Public education has been an important focus of both ongoing research projects in B.C. and has met with very positive results.

II. RECOVERY

Recovery Goals

The primary goal of the Recovery Team is to achieve and ensure a self-sustaining meta-population of badgers throughout their historic range in British Columbia.

This will be realized by attaining the following secondary goals:

1. stop decline in badger populations in British Columbia by reducing known mortality, especially road-kill and persecution.
2. ensure habitat is available to badgers throughout their historic range
3. restore badger populations to viable levels.
4. increase public awareness and understanding of badgers' role in grassland, pasture and open forest ecosystems of British Columbia's southern interior.

Short-Term Recovery Objectives

Short-term recovery objectives are divided into 1) intensive management objectives deemed necessary to ensure continuation of the species in British Columbia; and 2) those designed to increase our understanding of the ecological role and functioning of badgers. These are first listed and then expanded upon below. Quantified benchmarks are outlined for each objective in the Evaluation section below.

1. stop population decline
2. protect habitat
3. restore habitat
4. increase public awareness and appreciation of badgers and their prey
5. fill knowledge gaps
6. augment populations where necessary
7. ensure continuing prey populations
8. seek legal protection

Figure 5 Landowner sign used in East Kootenay to promote stewardship.

Stop Population Decline.

Historical trapping numbers (Figure 4), current low densities and vacant habitat all suggest that a decline has occurred, although lack of past population estimates restricts our certainty. Further, Newhouse & Kinley (2000) document have documented the extirpation of badgers from previously occupied range in the Upper Columbia Valley.

To stop the decline, mortality must be reduced and recruitment increased. Attaining the following objectives will achieve this:

a) Reduce Highway Mortality

The high rate of road kill observed in British Columbia may be a leading cause of population decline. Roads tend to follow valley bottoms in British Columbia's largely mountainous topography. This is the same location as the best badger habitat and the two mix with lethal results for badgers.

This is a difficult obstacle to overcome as traffic volumes and road densities are expected to increase. Under passes may work well (B. Ruediger pers. commun.), however they are very expensive. Further, badger's large home ranges make identifying specific "trouble spots" difficult and both signage and speed reductions are known to have minimal compliance. The Recovery Team must work closely with British Columbia's Ministry of Transportation to develop a strategy to limit the number of road-kill badgers.

b) Reduce extermination killing

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 is helping to reduce this mortality source. These stewardship activities need to continue.

c) Increase badger fecundity

The implications of badgers being induced ovulators is poorly understood. Multiple breedings may be required, especially by dominant males. Current low population numbers and densities may preclude many female badgers from successful breeding. Delayed implantation, which is also a part of badger reproduction, may require females to be in peak physical condition for a pregnancy to develop. If sufficient food is unavailable, female badgers in marginal habitat who were successful breeders may not continue to full term and raise young.

The highest mortality levels are suffered by juvenile badgers. Even young that are born have poor odds at surviving to adulthood. Mortality sources as described above are often most pronounced on younger age classes. Reducing mortality should help increase recruitment in badger populations.

Habitat Protection and Restoration

Habitat loss and degradation is likely the primary factor limiting badger populations in British Columbia. Much work has been initiated on restoring grassland and open forest ecosystems through relieving in-growth and encroachment with thinning and prescribed fire (Gayton 2001). Other innovative methods are required to aid progress on this issue. Working with private landowners is especially important, maintaining large tracts of land and avoiding subdivision and housing developments from spreading further onto these lands that support a variety of species at risk, including badger.

The objective of the Recovery Team is to continue to work at maintaining and restoring habitat most suitable to badgers: grassland and open forests. Many organizations and agencies are committed to this objective including the Grasslands Conservation Council of B.C., the B.C. Cattleman's Association, South Okanagan Similkameen Conservation Program and the East Kootenay Conservation Program.

Measurable success can come by ensuring the availability of badger habitat throughout its current and historic range in British Columbia. Protection need not come via traditional means such as parks: given the expansive home ranges of badgers, this approach will not work. However, the importance of formal protected areas for badger conservation is not diminished. Habitat in parks such as Lac du Bois, Kikomum Creek, Vaseaux Lake and Kootenay National Park provide critical core ranges for badgers.

The majority of badger habitat in British Columbia is on private land. Success in protecting badger habitat will be measured in area secured under conservation covenants or forging stewardship agreements with land owners. Several land conservatories are committed to securing land with high conservation values through direct purchase or covenants. The Recovery Team will work closely with the groups to meet the objective of protecting and restoring badger habitat.

Augment Extant Populations

Extirpation events are commonplace with small populations. 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: a) the spatial relationship of the habitat through which individuals must move to disperse; b) dispersal characteristics of the species and c) temporal changes in the landscape structure. As wide-ranging carnivores, badgers meet the second criterion, but are susceptible to the other two.

Because of badgers' limited reproductive capacity including low juvenile survivorship and fragmented habitat, natural recolonization of historical range is unlikely. Augmenting existing populations by translocation of badgers into vacant, quality habitat within otherwise occupied range may be an efficient way to increase badger populations and distribution. There are several reasons to do this in the near future.

- Although badgers readily dig new burrows, they appear to prefer those already dug and there are energetic benefits to doing so. Releasing badgers to habitat with burrows facilitates this as well as likely making new badgers "feel more at home" than in areas without burrows (Newhouse and Kinley 2001).
- Translocation of badgers to B.C. at this time would be considered 'augmentation' rather than 'reintroduction. Augmentations are more likely to be successful than 'reintroductions' (Griffiths et al. 1989). Although badgers would be released to vacant habitat, they would likely interact with nearby badgers increasing the chances of successful reproduction.
- Augmentation of existing populations is also preferable to reintroduction because the latter have low success rates near a species' range periphery and for carnivores generally (Griffiths et al. 1989; Wolf et al. 1996).
- Badger populations may be showing signs of inbreeding depression. Decreased viability and lowered fecundity are symptoms of inbreeding (Lande 1988; Simberloff 1988), both of which are being observed in *jeffersonii* badgers. Augmenting individuals will enhance genetic variation and hopefully reduce the chances of inbreeding and its consequences.

- Badgers are thought to be induced ovulators (Wright 1963 in Messick 1987), a condition where female fertility is increased by number of copulations and male fitness. Increasing population density through augmentation may help increase recruitment and, ultimately, population size.
- Finally, augmenting badger populations now will take advantage of the public relations work laid down by the current research projects. Badgers are still part of the cultural landscape within B.C.'s southern interior and their awareness and appreciation have been greatly increased of late. Social acceptance of "importing" badgers is easier now with an extant local population than later, were they to become more widely extirpated either regionally or provincially.

Worth noting is that any translocation is undesirable and the RT looks to this objective with reluctance. Translocation places large stress on individuals, is expensive and often does not succeed. The RT will focus efforts on habitat restoration and ameliorating circumstances within British Columbia that have led to the badgers' decline. However, translocation may be necessary to help "kick-start" recovery and is much more likely to succeed with native badgers nearby.

Ensure a reliable prey source

Ground squirrel ecology is poorly understood in British Columbia. Work should continue to not only increase that knowledge, but to protect ground squirrels and other important prey species including yellow-bellied marmots and several microtine rodents. Ground squirrels are not generally popular, especially with ranchers, golf course managers and other land owners. Like badgers, raising their ecological importance will best come through long-term education.

Legal Protection

Currently badgers are legally protected from trapping and all killing on public lands. However, badgers may still be killed on private land where they or their burrows are deemed a problem or dangerous, especially to livestock. Similarly, legal protection for prey is currently restricted to provincial lands.

Full legal protection can be applied under the B.C. Wildlife Act, if it is listed as an 'endangered species.' This designation is distinct from its current 'Red-listed' status by the provincial Conservation Data Centre (B.C. Ministry of Sustainable Resource Management). Red-listed species are under consideration for formal designation as threatened or endangered by the BC Wildlife Act. However, few species are formally designated.

Badgers are currently under review for British Columbia's "Identified Wildlife Management Strategy" (Adams & Kinley 2002). This provincial initiative falls under the B.C. Forest and Range Practices Act and provides some added protection for badgers during forestry and range management planning. Options under other provincial legislation (e.g. pesticides, Community Charter, etc.) have not yet been examined.

Although potentially useful, legislation is the least desired option to protect badgers and their prey. Management of other endangered species by enforcing or threatening legislation has been controversial (e.g. Jaimet 2001) and may diminish the positive cooperation to date with many land owners. While having a legal protection option is desired, employing it must be done carefully and only as a last resort.

Education and Communication

A practical and effective communication strategy is an essential component of conservation work (Jacobson 1999). To date, much success has been realized in raising public awareness and appreciation of badgers. Work toward this goal will help increase participation in private land stewardship, ensuring maintenance and restoration of badger habitat. Removing negative perceptions of badgers as dangerous and aggressive animals will reduce the number of individuals needlessly destroyed.

Fill Knowledge Gaps

Much remains unknown about badger ecology and effects of management actions. The Research Requirements section addresses the main knowledge gaps. That section should be used to direct future research and information needs.

Evaluation

Short Term Recovery Objectives will be evaluated using the following five year goals:

Protect and Restore Habitat

- Restore 30% of in-grown and encroached grassland and open forest habitats.
- Finalize private land covenants, easements or private land stewardship agreements that protect badgers and badger habitat. Regional targets have been set:
    - East Kootenay: Planning process by The Land Conservancy, The Nature Conservancy of Canada and the East Kootenay Conservation Program are developing area targets for stewardship of grassland ecosystems (K. Sheppard pers. commun.; D. Hillary pers. commun.). The RT will adopt these targets and cooperate with these partners to achieve them.
    - South Okanagan – Similkameen: 31,500 ha of grassland / shrub-steppe habitat and 23,500 ha of coniferous forest (SOSCP 2001). Note that not all this area may be considered badger habitat.
    - Thompson / North Okanagan: no targets have been set.
- Badger habitat requirements will be included in all land use planning exercises where badgers are known. Examples include: Land Resource Management Plans (LRMPs); Official Community Plans (OCPs).
- 30% of all golf courses in the badger's B.C. distribution will be promoted as "badger friendly" by eliminating rodenticide and other ground squirrel or badger extermination policies.

Reverse Population Decline / Increase Population size

- Increase total badger population in British Columbia to 300 adults (based on research and monitoring results and expert opinion).
- Reduce total annual road and rail kill levels to <5% of provincial population (assume known road and rail kill = 25% of total road and rail kill mortality).

- No mortality of badgers due to persecution perceived by landowners as "problem wildlife". (n.b.: this will be difficult to measure as the RT and wildlife managers are unlikely to know about landowners who do kill badgers.)
- Work with adjacent States (Montana, Idaho, Washington) for more conservative management of their badger populations. Close or restrict hunting and trapping seasons on badgers in neighbouring counties.

Augment Extant Populations

- Develop translocation strategy including criteria (when to consider translocation), methodology, post-release monitoring and assessment.
- Translocate 10 badgers to vacant habitat and closely monitor their movement and survival.

Ensure a reliable prey source

- Ensure ground squirrels (and other prey) are included in pre- and post-treatment monitoring of relevant ecosystem restoration programs.
- Develop methodologies to inventory population and establish benchmarks for prey species.
- Reduce number of permits issued to poison ground squirrels by 15%, achieved largely through public education.
- Improve range condition and grassland structure to provide habitat for small mammals.

Provide Legal Protection

- List as "Endangered" under B.C. Wildlife Act by March, 2004.
- Provide alternatives to landowners prior to destroying a "problem" badger on private property; amend B.C. Wildlife Act if necessary.

Educate Public and Communicate Results

- Complete and implement Communication and Education Strategy.

Conduct Research to Fill Knowledge Gaps

- Publish 3 peer-review publications on badger ecology and management in British Columbia
- Present at 5 major conferences on ecology and wildlife management.

Recovery Potential & Rationale

Ecological and technical feasibility of species recovery

The COSEWIC status update report (Newhouse and Kinley 1999) based the badger's designation as endangered in B.C. on the following criteria:

- small population size (now estimated at less than 200 adults)
- apparent continuing population decline
- poor demographics (limited capacity for population growth)

- fragmented and threatened habitat
- large home ranges

Under COSEWIC's current criteria for Endangered Species (COSEWIC 2001) badgers may be classified as "Endangered" under two categories:

- Category C-2-a-i: Small total population size (<2,500) and continuing decline of fragmented populations <250 mature individuals.
- Category D-1: Very small or restricted population with less than 250 mature individuals.

To reverse this status and thereby downlist badgers, the current decline must either be stopped, reversed or shown not to exist and the total badger population in B.C. increase to >250 mature individuals.

Based on trapping returns (Figure 4), badgers were historically much more abundant in British Columbia. This suggests recovery may be possible. However, significant recovery of badgers may not be feasible, primarily due to habitat loss and alienation throughout the 1900s.

Maintaining the subspecies as 'Endangered' may be the most realistic goal for badgers in British Columbia. Recovery is impeded by the following:

- limited reproductive capacity of the species
- naturally low juvenile survivorship
- high highway mortality
- limited options for habitat restoration in much of their range
- significant likelihood of continued habitat loss
- small populations naturally isolated with unknown amounts of movement between them.

Anticipated Conflicts or Challenges

a) Highway mortality

This will be difficult to mitigate. Most quality badger habitat in B.C. has a highway running through it, many with substantial traffic volumes. Further, badger behaviour leaves them particularly vulnerable to road-kill and their large home ranges makes identifying highway 'hot spots' difficult.

Infrared cameras that can detect animal movement and flash warnings and speed reductions are being used on a trial basis by the Insurance Corporation of British Columbia (provincial crown corporation for auto insurance). However, units are expensive, and may not be efficient on relatively small animals such as badger.

b) Habitat

In many parts of badger range, work has begun on restoring grassland and open forest ecosystems by reversing forest in-growth and reintroducing fire. However, more important than restoration of grassland and open forest ecosystems is the on-going loss of large areas of habitat likely permanently lost to urban development. Many of these areas also present movement barriers.

c) Extermination

Some landowners continue to have disregard for badgers and their digging ways on their property. Others may support badgers, but have little patience for their prey, especially northern pocket gophers. Another factor negatively affecting badgers is perceived aggression by the animal and subsequent fear of some people which can lead to needless killing of badgers.

Landowner contact and education has been ongoing for several years, with substantial results. Continuing to raise appreciation for badgers as ground squirrel predators and an integral part of interior B.C. ecosystems will erode any remaining negative values towards badgers and misunderstanding. Although our objective is to achieve zero mortality due to extirmination killing, some continued mortality is anticipated.

III. INITIAL ACTION PLAN

Approaches for Recovery

Partnerships

A single-species approach to recovery will be required to address specific concerns related to badgers. Many of the knowledge gaps listed below are species-specific. However, many factors related to badger decline are threats common to several other species at risk throughout British Columbia's southern interior, such as habitat loss, highway mortality and extermination. The RT and its associated Recovery Action Groups must work with other recovery groups, land stewardship organizations and restoration initiatives underway. These include:

- South Okanagan / Similkimeen Conservation Program
- East Kootenay Conservation Program
- Grasslands Conservation Council of British Columbia

These groups are broad coalitions of groups and/or agencies working on habitat or ecosystem restoration and protection. Working in cooperation with these groups as well as regional land use planning processes and land acquisition initiatives (e.g. The Land Conservancy of British Columbia and Nature Conservancy of Canada and others) will ensure that consideration of badger ecology is part of ongoing conservation efforts throughout the southern interior.

Land Use Planning

A number of Land Resource and Management Planning processes are underway or under review across badger range in British Columbia (e.g. Kootenay-Boundary, Okanagan/Shuswap, Kamloops). Badgers, as provincially red-listed and federally endangered, and their prey should be accounted for in these processes.

Recovery Action Groups

Recovery Action Groups (RAGs) are an effective means to work on specific projects or programs within the overall recovery efforts of the RT (RENEW 2001). RAGs may be specific to geographic areas, recovery objectives, or taxonomic divisions. Three RAGs will be established: the two geographic-based RAGs that will build on the research and conservation efforts to date; and a third to oversee education and communication efforts. RAGs are recommended to be limited to no more than ten people.

Each Geographic RAG is recommended to include the following representation:

- Project Leader. e.g. Kootenay: Nancy Newhouse; Thompson/Okanagan/Boundary: Rich Weir
- MWLAP Regional Endangered Species Biologist
- Local First Nations
- Corporate and Industry: e.g. forestry, agriculture/ranching, golf courses, tourism.
- Municipal and/or Regional Government
- Local ENGOs
- Key Partners

a) Kootenay Region

This will include the East and West Kootenay areas, as defined by the provincial Ministry of Water, Land & Air Protection (Region 4 on Figure 3).

b) Southern Interior Region

This will include the Thompson, Okanagan, Cariboo, Boundary and Nicola regions (Region 3 and SW corner of Region 5 on Figure 3).

c) Education & Communication

To date, both research projects have initiated substantial and successful programs for public education and communication of badgers' need for conservation. The RT will continue to build on these successes and achievements. While each geographic RAG is anticipated to continue local education efforts, a separate RAG should be formed to guide overall communication of badger conservation and research across British Columbia.

Currently web sites are maintained by each project with a third under development by Parks Canada. One internet location that covers all badger research and conservation efforts in British Columbia is desired.

One RAG directing communication will avoid duplication of effort and funding, ensuring more money is available for each RAG to conduct its research and management programs. It will also ensure a consistent and updated message being communicated to the public and interested organizations as well as providing key contact information.

The following membership for the Communication RAG is recommended:

- Geographic RAG project leader
- Recovery Team chair
- Communication specialists from key partners (e.g. Parks Canada, Grasslands Conservation Council of B.C., Forest Research and Extension Partnership).
- Temporary members specializing in specific task at hand

Summary of Strategies

A summary of strategies to achieve recovery objectives is provided in Table 6.

Table 6 Summary of actions to achieve Recovery Objectives. Organization column indicates who will take the lead. Where both RT and RAGs are listed, some involvement by the RT is anticipated to cover the provincial distribution of Badgers. (Ko RAG = Kootenay RAG; SI RAG = South-central Interior RAG; C+E RAG = Communications & Education RAG)

Priority	Objective	Specific Steps	Anticipated Effect	Organization
1	Stop Population Decline	• address highway mortality • minimize persecution	Increase population	Ko , SI RAGs & Recovery Team
1	Education & Communication	• public presentations & publications • promote private landowner stewardship • website consolidation & maintenance • produce newsletter	Increase awareness and appreciation of all grassland species and role of carnivores	C+E RAG
1	Habitat Protection [1]	• covenants, easements • stewardship agreements • acquisition	Increase population	all RAGs & Recovery Team
1	Fill Knowledge Gaps	• conduct & disseminate research	Better able to address needs	Ko and SI RAGs
1	Habitat Restoration [1]	• prescribed fire • stand tending • improve management of grassland ecosystems	Increase population	Ko and SI RAGs
2	Increase Population	• Enhance recruitment • Augmentation if necessary • Identify source populations and available habitat	Raise fecundity Increase population	Ko and SI RAGS
2	Ensure food supply	• Increase knowledge of diet • Increase knowledge of prey populations dynamics and requirements • Increase public acceptance of prey	Increase capacity to provide prey resource	Ko and SI RAGs C+E RAG
3	Legal Protection	• List as Endangered under Wildlife Act • List as Identified Wildlife under Forest and Range Practices Act	Decrease mortality Protect habitat on crown land	Recovery Team and B.C. Government

1. There are several organizations mandated to conduct these activities (see *Partnerships* above). The RT and RAGs do not propose to duplicate effort, but will support and, where possible, contribute to efforts to protect and restore badger habitat.

Knowledge Gaps

Survey Requirements

a) Distribution and Abundance

Research efforts to date have focused on the East Kootenay and Thompson / North Okanagan areas. These projects have described habitat use and provide a measure of distribution and population size. However, badger distribution and abundance are poorly understood in other regions of British Columbia.

The South 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. Very little is known about badger distribution and abundance through the Nicola, Cariboo, Boundary and West Kootenay regions.

Questions:

- Where are badgers on a provincial scale and in what relative abundances?
- What is burrowing habitat?
- Are badgers occupying alpine habitat throughout their range in BC?

Needs:

- Establish a provincial sighting database, possibly one that could be used as a long term index.
- Need regional reference sights to monitor distribution and abundance.
- Need to collate historic trapping data.
- Identify focus areas for sightings (and possibly burrow) surveys to test movement hypotheses.
- Need to describe ecological characteristics of burrowing habitat (soil, range condition, aspect etc.)
- Need to develop a usable (for the public) badger identification card.

b) Movement

The Boundary and West Kootenay region in particular may represent an important linkage between the two main badger populations in the province. More knowledge is also required regarding movement of badgers between populations and elsewhere.

Questions:

- Are badger movements more north-south along valley bottom lines and interacting with populations in the U.S.A.?
- To what degree do badger populations within British Columbia 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.t. jeffersonii*), the other not (*T.t. taxus*) (Newhouse and Kinley 1999)?

c) Methods

Obtaining population estimates of badgers is currently an extremely expensive and time-consuming process that involves invasive capture techniques. Developing inventory techniques that provide reliable and inexpensive population estimates is important to measure the success of other recovery efforts to increase badger numbers across their distribution.

Questions

- Can active burrows be used as a presence/absence indicator or population index effectively?
- How can we count badgers? Non-invasive options include: hair snags for DNA mark/recapture techniques (Mowat and Paetkau 2002; Foran et al. 1997) and aerial surveys for active digging.

Needs

- Independent trials of a variety of indices within an intensively monitored population (e.g. maintenance of core home range, number of family groups reported, fresh digging).
- Develop of techniques for DNA sample collection.

Biological/Ecological Research Requirements

a) Diet

Columbian ground squirrels appear to be the main constituent in badger diets in B.C.. However, the degree to which badgers are reliant 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 (C. Hoodicoff unpublished data; R. Packham pers. commun.). Also, juvenile badgers in particular may be more reliant on other 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?
- Diet requirements of juvenile age classes are particularly poorly understood.
- Winter diet – are badgers dependant 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
- Regional/seasonal/sex- and age-related monitoring of food habits
- Non-destructive technique for collecting scat from burrows; and large volume of scat samples

b) Prey Ecology

Badger research in British Columbia to date has suggested that proximity to ground squirrel colonies is a strong predictor of badger location. A substantial body of literature exists on various aspects of Columbian ground squirrel ecology (e.g. Dobson and Oli 2001; Neuhaus and

Pelletier 2001; Bennett 1999; Dobson et al. 1999) but may not be directly pertinent to badger ecology or British Columbia. Prior to initiating any research on Columbian ground squirrels in British Columbia, a thorough review of relevant extant literature should be completed.

Increased knowledge on what regulates ground squirrel populations (which are also at their range limit, as are secondary prey species such as yellow-bellied marmot and northern pocket gopher) should greatly help explain badger distribution and dynamics.

The effects of cattle and horse grazing on habitat of badgers and their prey are not well understood. Grass and forb communities provide basic food requirements to Columbian ground squirrels, but how squirrels respond to grazing is not clear. Richardson ground squirrels respond positively to over-grazing (Krausman 1996). Similar observations have been made with Columbian ground squirrels in British Columbia (N. Newhouse unpublished data; C. Hoodicoff unpublished data), but have yet to be properly tested. However, where ground squirrels are not present, badgers appear to rely on microtine rodent populations. These small mammals are likely negatively impacted by poor range condition (i.e. over-grazing) and may require the cover provided by late-seral grassland stages (R. Packham pers. commun.).

Understanding variation in prey populations, (e.g. cycles, colony establishment and abandonment) will increase our understanding of badger persistence.

Columbian ground squirrels have lower population densities than most other *Spermophilus* species (A. Hubbs pers. commun.). This could account for a more scattered distribution of badger prey in British Columbia where other ground squirrel species are unavailable, except golden-mantled ground squirrel which is generally restricted to higher elevation forest clearings.

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's use of non-traditional habitats (e.g. forested and alpine)?

Needs

- Problem analysis/literature synthesis on prey ecology as it relates to badger ecology.
- Baseline descriptive ecological studies on major prey species (particularly ground squirrels and pocket gophers.
- Monitor prey responses to restoration.

c) Autecology

Much has been learned of badger ecology in British Columbia in recent years. However the research has also raised many questions. More knowledge on the following will provide a better understanding of badger ecology and their requirements for recovery.

Use of Non-traditional Ecosystems. Badgers are traditionally thought of as grassland predators. Alpine ecosystems are similar in that both generally lack trees, but were not considered 'available' badger habitat until transmittered badgers were located there. We do not know to what extent alpine ecosystems play a role in badger ecology in British Columbia. Are badgers

transients there in snow-free seasons, or are they year-round residents? Results to date are equivocal, so more information is required.

Similarly, montane forest ecosystems are used by badgers in British Columbia (Apps et al. 2002; Weir & Hoodicoff 2002). These areas are often characterized as 'not-sufficiently re-stocked' early-successional forest stands following logging and/or wildfire disturbance. Like the alpine, the importance of these ecosystems for badgers near their range limit is unknown.

Females. Especially in the Thompson / Okanagan region, few females have been captured. Is this due to low female numbers or 'trap-shy' behaviour? What are their survival rates, reproductive rates, etc. ? Are natal dens regularly re-used and requiring increased protection?

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

Questions

- Is there another ecotype of badgers which uses only alpine habitats?
- Do badgers use forested habitats extensively anywhere and, if so, what prey are they dependent on?
- How long are cutblocks or old burns valuable habitat to badgers and how do various silvicultural activities influence this?

Needs

- Monitoring of badgers in alpine habitats
- Monitoring of badgers in forested habitats under various silvicultural regimes including non-harvested.
- Evaluation of prey abundance and availability in cutblocks of varying ages.
- Long-term monitoring of transmittered badgers to better define home ranges in a variety of habitats and prey sources.

d) Population Genetics

Badger populations in British Columbia seem to fit classic models of meta-populations: "a population of populations" (Hanski and Gilpin 1991). Individual badgers move freely within local populations (e.g. East Kootenay), but the extent to which individuals and their genetic material are transferred among populations (e.g. East Kootenay to Okanagan) is unknown. Given the apparent small population size, some amount of dispersal among populations is necessary to avoiding inbreeding depression, but how much is required and whether this is happening is unknown.

DNA samples are currently collected from all captured 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 U.S.A..

Questions

- Do badgers in BC move (disperse) within and between components of the hypothesized meta-population?
- What role does badger density play in determining home range size?

- Are some components (e.g. Thompson Region) of the badger meta-population limited by a scarcity of females

Needs
- Identify possible population units, starting with the existing genetic samples.
- Identify potential dispersal corridors (using habitat and topography models) between population units.
- Identify potential movement barriers (transportation and forest cover may be some of the data used here).
- Conduct mitochondrial DNA analysis of Thompson Badgers to determine minimum number of adult females.

Threat Clarification Research Requirements

a) Limiting factors

Although specific mortality sources have been identified, none have been implicated as a major factor limiting badger populations, due in part to low sample sizes. The COSEWIC status update report (Newhouse and Kinley 1999) cites habitat loss and degradation through agriculture and forest in-growth as well as loss of prey and extermination as primary factors limiting badgers in B.C. and elsewhere. Other factors, primarily demographic, have since been recognized as potentially limiting badger populations.

b) Habitat Loss

More information is needed on the effects of habitat loss to badgers in B.C. Questions remain as to what aspects of habitat loss are most limiting to badgers. Knowledge gaps include:

- dispersal habitat (possible bottlenecks around urban and agricultural developments that restrict movements both between and within populations)
- natal den sites – what characteristics are preferred by females for successful rearing of kits? Is less disturbance required, or are their needs relatively plastic?
- are there dependencies by badgers on specific soil types and do these relate to ability to burrow or provide required food for prey species?

c) Highway mortality

Road-kill accounts for a significant amount of mortality in badgers (Weir et al. 2001; Newhouse and Kinley 2001; Messick 1987). There are two issues here:

- are roadways attractive to badgers?
- how to reduce mortality

Answering the first question will hopefully help address the latter. Roads provide movement corridors for badgers, adjacent soils may be more friable and support greater prey populations for similar reasons. Are specific sex and age classes more susceptible to road-kill? There is a clear need for understanding the underlying causes of badger highway mortality (any of the above or alternatives such as aggressive badger behaviour). This will hopefully lead to effective mitigation measures to lessen the impacts.

d) Ground Squirrel Control

The prey items of badgers, particularly Columbian ground squirrels, are often the target of extermination by land owners. The extent to which this affects badgers either directly by loss of available food or indirectly via secondary poisoning (from eating dead, poisoned ground squirrels) is unknown. Killing ground squirrels and other prey is illegal on Crown Land in British Columbia, but permitted on private land for purposes of property protection.

Actions Already Completed or Underway

Two field-oriented research programs are currently underway.

East Kootenay Badger Project

The East Kootenay Badger Project, a long-term research and conservation project, has been underway since 1996. From 1996/97 to 2000/01, 20 badgers were implanted with radiotransmitters and regularly monitored, and their general ecology was described (Newhouse and Kinley 2001). 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 COSEWIC status update report (Newhouse and Kinley 1999).

From 2001/02 to 2003/04, the objectives of the research components of the project are to use radiotelemetry to assess badger population dynamics in the southern portion of the East Kootenay Trench, including home range size, reproductive success, and mortality causes and rates. Experimental translocation of badgers from Montana and follow-up monitoring began in 2002 and is planned to continue in 2003.

In 2001/02 significant gains were also made on conservation initiatives including 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.

Thompson / Okanagan Badger Project

Initiated in 1999, the Thompson/Okanagan Project is similar to East Kootenay project in collecting life history data on badgers for the purpose of conservation planning (Weir and Hoodicoff 2002). Based near Kamloops, field work has concentrated on the North Thompson and South Thompson River valleys.

The broad goals of the Thompson-Okanagan Badger Project are to determine the number and distribution of badgers in the region; describe their basic ecology; and determine the effects (both positive and negative) that people and their activities might have on badgers.

Specific objectives of the project include:

- Collect and compile existing information on the distribution and occurrences of badgers in the Thompson, Nicola, and Okanagan areas,
- Identify habitats required by badgers by examining habitat selectivity at a variety of spatial scales,
- Create habitat management guidelines for habitats that are critical or important to badgers,

- Identify population factors (e.g., mortality factors), land use issues, habitat suitability issues and prey base issues that may affect the conservation of badgers in the region,
- Facilitate population assessment work by testing and refining Resources Inventory Committee (RIC) inventory methods for badgers,
- Create conservation strategies based on scientific data for the species,
- Develop realistic management guidelines for ranchers and farmers so that they can reduce their effects on badger populations without substantial decreases in the productivity of their operations,
- Create public awareness regarding the status and issues surrounding badgers and other grassland species in the Southern Interior Region through education programs,
- Develop distribution and capability maps based on known occurrence data, a regional species account and ratings methodology (BC Wildlife Habitat Ratings Standards), and
- Develop transplant methods for "problem" badgers, so that these individuals are not removed from dwindling populations.

Potential Management Impacts for Other Species/Ecological Processes

As an umbrella species, recovery of badgers will have an effect on other species that rely on grassland and open forest habitats. Work to ensure continuing prey populations, particularly Columbian ground squirrels, will directly benefit other predators, especially diurnal raptors.

Opportunities exist to cooperate with other programs and agencies to restore and protect badger habitat. Duplication of effort and competition for limited funding can be avoided by combining efforts, particularly relating to habitat with other programs. Development and delivery of an effective communication strategy that focus not just on badgers, but the grassland and open forest ecosystems of British Columbia's southern interior as a whole will benefit the broad suite of species, many also rare or endangered, that are dependent upon these areas.

IV. ADDITIONAL INFORMATION

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Scientific Names of Species listed in Text

Common Name	Scientific Name
Mammals	
American Badger	*Taxidea taxus jeffersonii*
Lynx	*Lynx canadensis*
Bobcat	*Lynx rufus*
Cougar	*Felis concolor*
Wolverine	*Gulo gulo*
Coyote	*Canis latrans*
Columbian Ground Squirrel	*Spermophilus columbianus*
Golden-mantled Ground Squirrel	*Spermophilus lateralis*
Richardson Ground Squirrel	*Spermophilus richardsonii*
Yellow-bellied Marmot	*Marmota flaviventris*
Red-backed Vole	*Clethrionomys gapperi*
Northern Pocket-Gopher	*Thomomys talpoides*

Birds	
Common Loon	*Gavia immer*
Golden Eagle	*Aquila chrysaetos*
Burrowing Owl	*Speotyto cunicularia*
Raven	*Corvus corax*
Reptiles	
Western Rattlesnake	*Crotalus viridis*
Gopher Snake	*Pituophis catenifer*
Trees	
Douglas fir	*Pseudotsuga menziesii*
Lodgepole pine	*Pinus contorta*

Acronyms

ALR – Agricultural Land Reserve
COSEWIC – Committee on the Status of Endangered Wildlife in Canada
RAG – Recovery Action Group
RENEW – Recovery of Endangered Wildlife in Canada
RT – Recovery Team
SOSCP – South Okanagan Similkameen Conservation Program
WLAP – B.C. Ministry of Water, Land & Air Protection

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