East Kootenay Badger Project 2005-2006 Progress Report:
Ecology, Translocation, Communication, Sightings and Habitat Use

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Chapter 1.

This chapter combines and finalizes the first 2 chapters from the 2005 progress report, and is intended for submission as a journal manuscript.

Ecology of an Endangered Range-Limit Badger Population and Use of Translocation to Aid Recovery

Abstract

Southern British Columbia, Canada, is the northwestern range limit of the American badger (*Taxidea taxus*), supporting a nationally endangered subspecies. We conducted radiotelemetry-based research within the Rocky Mountain Trench to gain an understanding of space-use, diet, and demography. During the 10-year study, there was evidence of extirpation within the northern part of our study area, yet the population remained strong in the southern portion. However, research effort shifted simultaneously in both time and space, so it was not initially clear whether conditions were more favorable for badgers in the south, or simply later in the study. We therefore investigated whether differences between north and south were more closely related to temporal or spatial effects. We also translocated badgers from northwestern Montana into the northern part of the study area to (a) more directly determine whether the north had permanently lost its capacity to support badgers or had merely experienced the temporal variability in population size expected at a range limit, and (b) initiate recovery.

In comparison to southern residents, those in the north had larger home ranges, lower survivorship, no known reproduction and negative rather than positive projected growth ($\lambda = 0.7$ vs 1.2). However, litter size, number of ground squirrels consumed, and home range size were all correlated to both latitude and date of research. Survivorship was greater later in the study for both northern and southern animals. Both groups had a varied diet with similar proportions of empty stomachs and samples containing Columbian ground squirrels (*Spermophilus columbianus*), the main prey. In comparison to females, males had larger home ranges and had later and longer juvenile dispersal. We recorded home ranges that varied from being similar to those in other studies to, in the case of northern males, several orders of magnitude larger. Translocated animals and their offspring had kit production equivalent to that of southern residents, adult survivorship intermediate between the 2 groups and no confirmed mortality of tagged kits, with population growth projected ($\lambda = 1.3$). They were similar to residents in proportion of samples containing ground squirrels or lacking animal remains. Home ranges of translocated females were intermediate between (though not significantly different than) the 2 resident groups, and those of translocated males appeared larger but were not significantly different than either resident group. Juvenile dispersal dates and distances were similar to those of residents for each sex, though with some indication of an earlier date for translocated animals among males. Among translocated animals, home ranges were larger for males, but the sexes did not differ in timing or extent of juvenile dispersals.

Our results were consistent with the extirpation of the northern population being related to fluctuations over time in environmental and human-related conditions or the effect of random events expected at range limits. It did not appear to have been primarily due to any permanent loss of the northern area's capacity to support badgers. At 3.5 years after starting translocations, the northern portion of the study area had badgers present in an apparently growing population. Concerns remain about several factors that have or may have contributed to mortality and previous population declines in the north, but translocation appears to be a useful tool to test and in some cases counter the fluctuations typical of rare, range-limit species.

Introduction

The northwestern limit of American badger (*Taxidea taxus*) distribution is within southern British Columbia (Newhouse and Kinley 2000). The subspecies present there is *T. t. jeffersonii* (Long 1972), which is listed as endangered in Canada (COSEWIC 2003). It is also "red-listed" by the provincial Conservation Data Centre due to large home ranges, declining populations, loss of habitat and prey, and potential for high mortality from roadkills and shooting (Cannings et al. 1999). There has been no trapping season for badgers in British Columbia since 1967, and no hunting season.

Badger research from other jurisdictions has been conducted in open, agricultural landscapes (Salt 1976, Todd 1980, Lampe 1982, Warner and Ver Steeg 1995) and grassland or shrub-steppe habitats (Messick and Hornocker 1981, Goodrich 1994, Hoff 1998), although they are known to occur from below sea level to elevations over 3,600 m (Lindzey 1982). In British Columbia, they occur mainly within open habitats at lower elevations in the southern part of the province (Rahme et al. 1995, Newhouse and Kinley 2000, Apps et al. 2002). There is considerable regional variation in home range size, but all studies have found males to have larger home ranges than females (Messick and Hornocker 1981, Minta 1993, Goodrich 1994, Warner and Ver Steeg 1995, Hoff 1998). Fossorial prey is the primary diet in most locations (Salt 1976, Lampe 1982), but badgers also eat a wide variety of mammals, birds, eggs, reptiles, amphibians, invertebrates, and plants (Messick 1987). Data from Idaho suggest that conception generally occurs in late July and August, with litters of 1 to 4 born from mid-March to mid-April (Messick and Hornocker 1981).

Given British Columbia's peripheral location within badger range and its population of only 250-600 animals distributed over 120,000 km^2 (Newhouse and Kinley 2000), we anticipated that badger ecology might differ from that reported for jurisdictions more central to badger range. Therefore, in 1996, we initiated telemetry-based research in southeastern British Columbia to gain an understanding of space-use characteristics, diet, and demographic trends of this endangered, range-limit population. During the

10-year study, there was evidence that the population was at or near extirpation within the northern part of our study area (where research began) while remaining relatively strong in the southern portion (where research was completed). Because of this simultaneous shift of research effort in both time and space, we investigated whether the observed demographic differences between north and south were more closely related to temporal or spatial variability in the ability of the study area to support badgers. We also determined demography, space use and diet of badgers translocated from northwestern Montana to the northern portion of our study area beginning in 2002, to test this question more directly. That is, we used translocation to determine whether the apparent erosion of the north's ability to support badgers reflected a permanent loss or merely temporal variability in population size at this range limit. Associated with this goal was the aim of re-establishing a badger population in the recently-extirpated portion of the Trench. Classification by Long (1972) suggests that northwestern Montana supports the same subspecies as British Columbia. Consistent with this, badgers in southeastern British Columbia are genetically more similar to those of northwestern Montana than Alberta or eastern Montana (Kyle et al. 2004). In contrast to their status within British Columbia, badgers in Montana are classified as non-game wildlife with commercial value (Montana Fish, Wildlife and Parks 2002) so are subject to trapping and shooting without bag limits or seasons and, on private land, can be legally poisoned.

Study Area

Our study area in southeastern British Columbia, Canada, was centered on the Rocky Mountain Trench from 49°N (USA border) to 51°N. The Trench has a minimum elevation of 695 m and separates the Rocky Mountains to the east from the Purcell Mountains to the west (maximum elevations of 3,618 and 3,457 m respectively). Biogeoclimatic zones in this region follow an elevation sequence from the Ponderosa Pine (PP) zone at the lowest elevations in the warmest, driest areas, through the Interior Douglas-fir (IDF), Montane Spruce (MS), Engelmann Spruce – Subalpine Fir (ESSF) and Alpine Tundra (AT) zones, with the Interior Cedar – Hemlock (ICH) zone occurring in place of the MS in areas receiving greater precipitation (Braumandl and Curran 1992). The PP and IDF correspond approximately to the Rocky Mountain Trench. These zones were historically dominated by open forests of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) respectively on zonal sites, grasslands or grass-shrublands on more xeric sites, and extensive marsh and forested riparian habitat along rivers. However, human settlement within the IDF and PP has resulted in much residential, recreational, road, and agricultural development along the valley bottoms, along with conifer encroachment into formerly open habitats due to fire suppression (Machmer 2002). Climax forests in the MS are closed-canopy stands of hybrid white spruce (*Picea glauca* x *engelmannii*), in the ICH are western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) and in the ESSF are Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). However, the MS, ICH and ESSF have an extensive history of fire and timber harvesting, so also include roads, cutblocks, burns, and forest stands of varying ages with a high proportion of lodgepole pine (*Pinus contorta*) and other tree species. The AT is non-forested.

Potential fossorial and semi-fossorial prey using open habitats include Columbian ground squirrels (*Spermophilus columbianus*), which occur in natural or human-caused openings in all biogeoclimatic zones; northern pocket gophers (*Thomomys talpoides*), which are patchily distributed at the lowest elevations in the PP and IDF in the southern end of the study area; chipmunks (*Tamia* spp.), mice and voles (*Peromyscus maniculatus*, *Zapus princeps*, *Clethrionomys gapperi*, *Phenacomys intermedius*, *Microtus* spp.); and hoary marmots (*Marmota caligata*) which occur sporadically in the AT.

We monitored radiotagged badgers making forays into the Rocky and Purcell mountains, but almost all research and badger activity occurred within a 4,000-km^2 area of the Rocky Mountain Trench or at the mouths of major tributary valleys. The northern and southern portions of the Trench differ in several respects. North of 49.9ºN, the Trench is narrower (3-12 km versus 12-30 km wide), lacks pocket gophers, lacks the PP zone, has slightly higher valley-bottom elevations, includes several locations where villages or resort communities extend across at least 1 side of the Trench from valley floor to mountainside, and includes the normal limit of badger distribution.

Translocated badgers were trapped near the southern end of the Rocky Mountain Trench in the cities of Kalispell and Whitefish, Montana, USA, and at the southern end of the Salish Mountains, 30-50 km west of Kalispell. All translocated badgers were trapped in areas classified as IDF (Demarchi et al. 2000).

Methods

<u>Capture and Handling - Residents</u>

In British Columbia, we identified trap sites by field-checking locations of sightings reported by members of the public, areas where we detected badger burrows, known colonies of Columbian ground squirrels, and (to capture kits or to replace failing radiotransmitters) the burrows of already-tagged badgers. We trapped badgers at burrow entrances, generally using unbaited #1$^1/_2$ soft-catch leghold traps, and checked traps at least daily. We noosed and hand-injected trapped badgers with either 10 mg/kg of tiletamine hydrochloride/zolazepam hydrochloride mixed at 100 mg/ml, or a combination of 0.3 mg/kg of midazolam mixed at 1.0 mg/ml and 9 mg/kg of ketamine hydrochloride mixed at 100 mg/ml. Surgical implantation of intraperitoneal transmitters (Advanced Telemetry Systems, Isanti, Minnesota) was conducted either in a veterinary clinic or in the field following Hoff (1988). While badgers were immobilized, we took samples of blood, feces and hair, and an upper premolar tooth. When badgers were alert, we released them either at the original trap sites when burrows were still intact, or at nearby burrows. Teeth of adult study animals were sent to Matson's Lab (Milltown, Montana) for aging. All methods were approved by the British Columbia Animal Care Committee, which at that time was under the auspices of the Ministry of Water, Land and Air Protection (WLAP), Victoria, British Columbia. WLAP also issued annual scientific permits for collecting samples, radiotagging and tracking.

Capture and Handling - Translocated Badgers

The general location for trapping of badgers translocated from Montana was selected by Montana Fish, Wildlife and Parks (FWP) staff based on high-density badger populations. Those captured in Kalispell and Whitefish were targeted due to complaints arising from badgers burrowing in urban areas. All handling methods were the same in British Columbia except that badgers from Montana were dewormed, had flea ointment applied, and were transported to the USA-Canada border for inspection by a Canadian Food Inspection Agency veterinarian. Seven of the translocated badgers were released the day after capture, while 7 were released after 2 days and 2 after 3 days due to the temporary unavailability of veterinarian services or inspection personnel. We released badgers at existing but currently unoccupied badger burrows within active Columbian ground squirrel colonies. We selected release sites based on:

- location in the northern portion of the study area (i.e. north of 49.9°N);
- high habitat quality extending over a large area, as indicated by recent habitat suitability modeling (Apps et al. 2002) and subjective assessments incorporating recent or imminent changes to habitat conditions;
- evidence of abundant ground squirrel populations;
- evidence of recent use by badgers;
- low risk of vehicle collisions (few roads and/or roads with little traffic); and
- relatively low levels of human settlement.

Kits born in British Columbia to translocated females were also radiotagged, following methods identical to those used for residents.

In addition to approval from the British Columbia Animal Care Committee, WLAP issued a permit to import, transport and release badgers; FWP issued a scientific collecting permit; we completed a United States Fish and Wildlife Service “Declaration for Importation of Exportation of Fish or Wildlife” for each badger; each animal was inspected by a veterinarian in Montana and issued an “Official Certificate of Interstate Movement” health certificate, then was checked at the border by a Canadian Food Inspection Agency veterinarian; and following augmentation, the Canadian Wildlife Service provided a permit under the Species at Risk Act to capture the kit of a translocated female occurring on federal land.

Monitoring

We monitored badgers aerially from June 1996 to February 2006, using standard radiotelemetry techniques (Samuel and Fuller 1996). Generally, we located animals weekly from April through September and twice-monthly to monthly from October through March, although the schedule varied with budget and weather. We located animals from the air using a telemetry-equipped Cessna 172 aircraft. In searching for badgers that were not readily located, we periodically extended monitoring flights in the Rocky Mountain Trench from 75 km northwest of the northernmost radiolocation southward to the area where translocated badgers were trapped, and up to 15 km into the Purcell, Salish and Rocky mountains, an area of about 20,000 km^2. For 41% of locations used in this analysis, we then employed ground-based telemetry to locate badgers in their burrows. Until 2000, locations were marked on 1:20,000 air photos and transferred to 1:20,000 provincial forest inventory planning maps, from which Universal Transverse Mercator (UTM) grid coordinates were determined. After Selective Availability (intentional error) was removed from American satellites in 2000, we used GPS units to record UTM coordinates. With the possible exception of some air-only locations, all data points were of badgers in burrows rather than above ground. When the mortality sensor on a radioimplant was motionless for 4 hours, it caused a doubling of the implant's pulse frequency. When detected, the site was visited, the carcass or implant was recovered to confirm that the badger had died, and evidence of the cause of death recorded where possible.

<u>Litter Size Determination</u>

We determined minimum litter sizes from direct observations of burrows of all radiotagged females 1 year and older. Females with litters tended to have large natal burrows (evident from large mounds of recently excavated soil), use a small area over several weeks, be active throughout the day, and bring prey back to the burrow. The most obvious indications of kit presence and numbers were that the kits typically spent considerable time playing aboveground at the burrow site. In addition, we checked all females at the time of capture for signs of lactation. For resident badgers, we developed linear regressions of litter size in relation to both UTM northing and year, and conducted F-tests for significance of regression equations. All statistical tests were performed with the program *JMP IN* (SAS Institute, Inc., Cary, North Carolina).

<u>Survivorship Determination and Population Projection</u>

We employed the modified Kaplan-Meier method to determine juvenile survivorship, following the staggered-entry technique described by Pollock et al. (1989). This was done for residents in the south and translocated juveniles and the offspring of translocated badgers in the north, but not for northern resident kits as none were detected or captured. We assumed a 15 April birthdate, analyzed the data as if all animals had been born in the same year, and terminated the analysis at 52 weeks. The survivorship function and 95% confidence intervals for each week were calculated and plotted. Badgers tagged as juveniles but surviving to 15 April were included in the adult sample thereafter. We also employed the modified Kaplan-Meier method to determine adult survivorship, both for residents and translocated animals (including descendents ≥ 1 year of age). The survivorship function and 95% confidence intervals for each week were calculated and plotted. Following this, annual adult survivorship was extrapolated by taking the n^{th} root of the cumulative weekly survivorship, where n is the number of years. All resident animals from the north died prior to the analysis completion date, so an extrapolation of annual rates using Kaplan-Meier methods would have either yielded a result of 0 if done after the final mortality or would have been unrealistically high if calculated immediately prior to the final mortality. Thus, annual adult survivorship was also calculated for all classes using the Mayfield method (Winterstein et al. 2001). For both methods, the date of death was assumed to be the midway point between the last live telemetry date and the date on which the animal was found dead, unless there was evidence of the exact time of death. For data censored due to telemetry contact being lost, the censure date was assumed to be the midway point between the last successful telemetry location and the first failed attempt thereafter. Doing so prevented the negative bias associated with using the last telemetry location or last live date as the censure or mortality date. One tagged female hit by a vehicle was treated and successfully released, but would otherwise have died, so was considered a mortality for the purposes of survivorship calculations and mortality-cause determination. She was re-entered into the survivorship database on the date she was released after recovery. We excluded data only from 1 animal surviving < 1 week after radiotagging.

For residents of each of the north and south and for the re-established northern population (translocated animals and their descendents) we estimated the geometric growth rate (λ) by adding the annual adult survivorship to the product of the proportion of females, kits observed per adult female and survivorship to age 1 of radiotagged kits. We assumed an even sex ratio, based on the trapped sample of residents.

Diet Analysis

Scats were manually extracted upon capture and digestive tracts were obtained upon retrieval of carcasses, when possible. Digestive tracts were also retrieved from non-tagged badgers hit by vehicles within the Trench and reported to us. All samples were sent to Pacific Identifications Inc. (Victoria, British Columbia) for identification of skeletal remains. We used Pearson chi-square tests to compare northern and southern residents with regard to the incidence of Columbian ground squirrels in samples, and the incidence of having no animal remains, then did the same in comparing northern residents to the re-established northern population. For residents, we also regressed the minimum number of Columbian ground squirrels per sample against both date and the UTM northing of each sample, then conducted F-tests for the linear regression equations.

Home Range Determination

Fixed kernel (FK) estimates of home range have been found to have lower bias and lower surface fit error than other methods (Seaman et al. 1999), so we estimated adult home range size as the 95% FK contour. We also estimated 95% adaptive kernel (ADK) and 100% minimum convex polygon (MCP) home ranges to facilitate comparisons with studies that used other methods, and in the case of MCP, also as an indication of the gross area covered by each badger. We calculated ADK and FK ranges with *The*

Home Ranger (Hovey 1999), using a grid resolution of 100 pixels and standardizing x and y coordinates with multivariate normal scores, and determined MCP ranges with the *Animal Movement* extension (Hooge and Eichenlaub 2000). In cases where sequential locations were < 4 days apart, we deleted the second telemetry location. Kernel home range estimates are influenced by sample size (Seaman et al. 1999). Animals with fewer than 25 locations or less than 1 year of monitoring (after their assumed first birthday on 15 April) were not included in calculations of mean home range. For resident badgers and the re-established northern population separately, we compared home ranges among sexes using Student's t-tests. We also used Student's t-tests to compare northern to southern residents, and both northern and southern residents to the re-established northern population. Among resident badgers only, we regressed MCP and FK home against median UTM northing and median date of telemetry for each of males and females, regressed median UTM northing against median date of telemetry, and conducted F-tests for the linear regression equations.

<u>Juvenile Dispersal Measurement</u>

Dispersal distance of animals tagged as juveniles was considered to be the maximum distance from the point of capture (generally the maternal burrow) recorded for the animal, regardless of the age at which this occurred. For resident juveniles, we used Student's t-tests to compare between sexes the age of initial dispersal (i.e. ≥ 1 km from the point of capture), maximum dispersal distance, and age at maximum dispersal. We developed linear regressions of maximum dispersal distance in relation to monitoring period for males and females separately, and conducted F-tests for significance of regression equations. The age at first dispersal (assuming a birth date of 15 April) was based on the midpoint between the last telemetry location at the maternal burrow and the first telemetry location > 1 km from it. For juveniles born into the re-established northern population, we determined age at first dispersal, age at maximum dispersal and maximum dispersal distances for males and females, then compared these among sexes and to resident animals. Badgers translocated as juveniles were not assessed, as there was no maternal burrow from which to measure dispersal, and all were rapidly lost from radio contact.

Results

<u>Northern and Southern Residents</u>

Between 1996 and 2002, we captured 16 male and 17 female badgers within the Trench. This included 3 adult males and 4 adult females (1 of which died due to complications from surgery) in the north, and 7 adult males, 6 adult females, 6 juvenile males (2 of which were too small to tag) and 7 juvenile females in the south. Only 1 of the northern animals was captured after 1998 because we detected burrows of only 1 non-tagged badger there from 1999 through 2002. Captures in the south were from 1997 through 2002. No significant trap-related injuries were detected. We obtained 1554 telemetry locations from these animals.

Ages of adults at the time of capture varied from 1 to 12 years (Figure 1). Juveniles are excluded from the chart as we often specifically targeted them for capture. A north-south comparison was limited by the small sample, but no gross difference in age class structure was evident. Mean and median ages of adult badgers in the north were 5.0 and 3 years, and those in the south were 4.6 and 4 years.

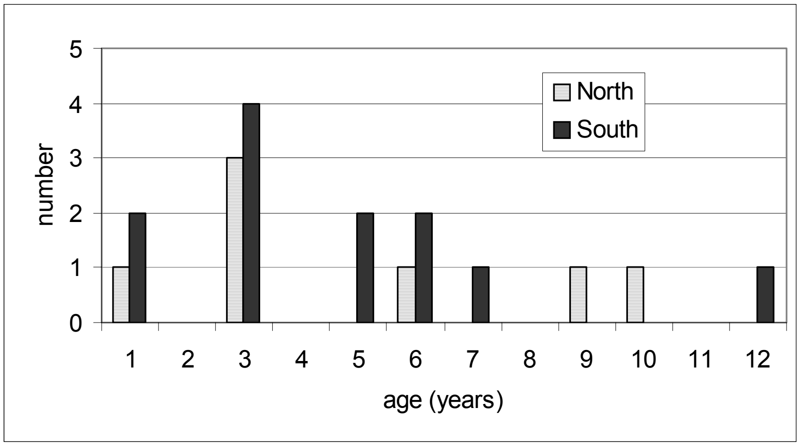

Figure 1. Age at capture of 19 resident adult badgers north (1996 - 2000) and south (1997 - 2002) of 49.9°N, Rocky Mountain Trench, southeastern British Columbia.

The latitude (UTM northing) at which radiotelemetry data were obtained from radiotagged animals was strongly correlated to date (Figure 2).

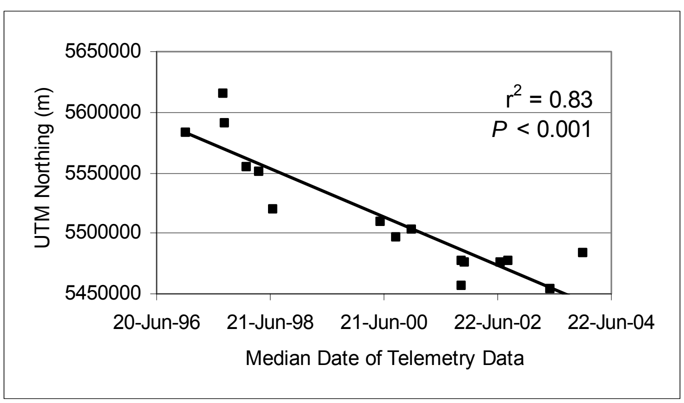

Figure 2. Median UTM northing in relation to median date of resident badger telemetry locations (sexes combined), Rocky Mountain Trench, southeastern British Columbia, June 1996 – February 2006.

Eleven females were observed for 1 to 4 kit-rearing periods each, providing a sample of 25 potential litters (animal-years). In the north, there were 0 kits observed in 10 animal-years (n = 4 adult females), while in the south there were at least 19 kits from 12 successful litters across 15 animal-years (n = 7 adult females). There was a tendency for litters to be larger farther south and later in the study (Figure 3). Two of 3 southern females observed at age 1 had successful litters, compared to 0 of 1 in the north. Initial litter sizes were probably larger than reported, as some kits likely died before they emerged from natal burrows, or were not observed.

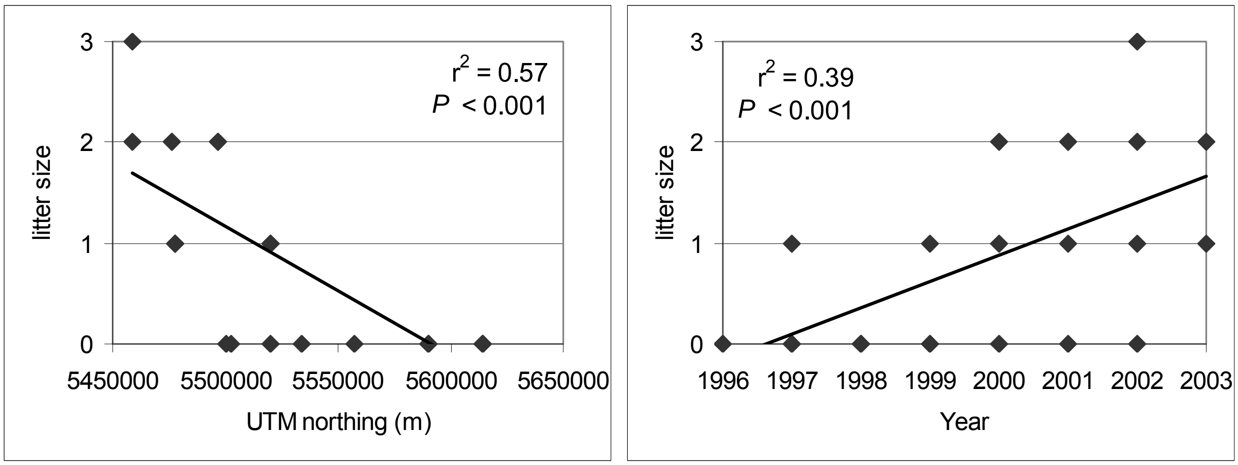

Figure 3. Mean litter size as a function of maternal den location and year for resident female badgers ≥ 1 year old, Rocky Mountain Trench, southeastern British Columbia, 1996 - 2003.

Of the 11 juveniles radiotagged (all from the south), 5 died in their first year of life and 1 was lost from radio contact, so 50% of known-fate juveniles survived from tagging to their first birthday. Annual Kaplan-Meier survivorship was 51%, with lower mortality from 6 months to 1 year of age (Figure 4). Mortality causes included 1 train kill, 1 probable starvation, 1 possible cougar or bobcat predation, and 2 unknown.

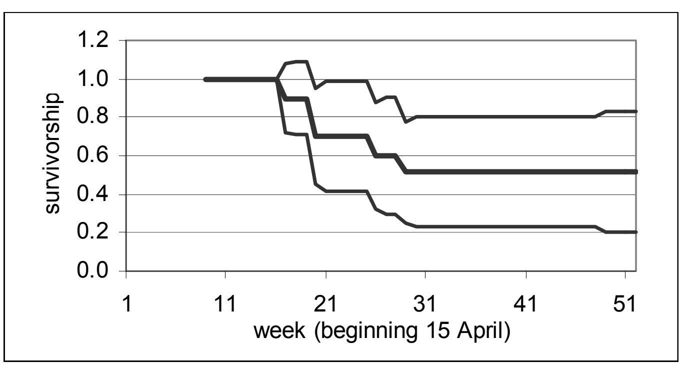

Figure 4. Kaplan-Meier survivorship (based on weekly intervals) and upper and lower 95% confidence intervals for resident juvenile badgers, Rocky Mountain Trench, southeastern British Columbia, July 1997 – April 2002.

Adult mortality causes included roadkill (4), probable cougar predation (1), probable bobcat predation (1), probable old age (1), and unknown (2). The oldest animal at the time of death was a female from the north, at 13.6 years. Annual adult survivorship values are indicated in Table 1. Cumulative survivorship curves for resident adults indicate a less rapid decline in cumulative survivorship (i.e. lower mortality rate) over roughly the last half of the study (Figure 5). Based on Mayfield survivorship estimates for the north, south and combined, λ = 0.7, 1.2 and 1.0 respectively. The same values were obtained using the Kaplan-Meier method for south and combined; no survivorship estimate was available for the north.

Table 1. Annual survivorship of resident adult badgers, Rocky Mountain Trench, southeastern British Columbia, June 1996 – February 2006.

Area/Sex	Annual Survivorship (%)	
	Mayfield	Kaplan-Meier
North - both sexes (n = 6)	68.1	[a]
South - both sexes (n = 13)	90.2	92.0
Both areas - males (n = 10)	83.8	82.6
Both areas - females (n = 9)	81.2	76.4
All animals (n = 19)	82.4	81.8

[a] could not be calculated; all animals died prior to end of monitoring period

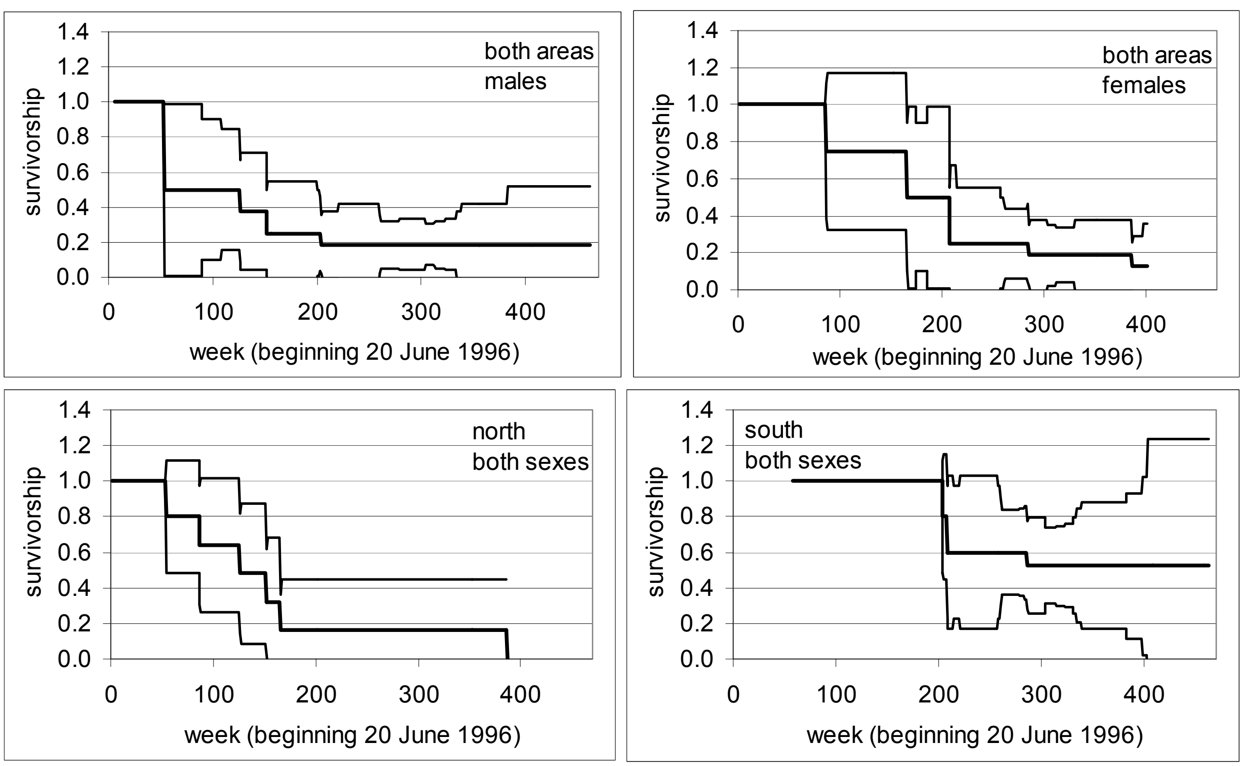

Figure 5. Kaplan-Meier survivorship (based on weekly intervals) and upper and lower 95% confidence intervals for resident adult badgers, Rocky Mountain Trench, southeastern British Columbia, June 1996 – February 2006. Data for “both areas, females” end with censoring of last animal (loss of radio contact); data for “north, both sexes” end with mortality of last animal.

Resident badger prey included fossorial rodents of open habitats, but also other rodents, birds, amphibians and insects (Table 2). There was no difference in the proportion of samples lacking animal remains between north and south (*P* = 0.885). There were also no north - south differences in the proportion containing Columbian ground squirrels when comparing the areas as two units (*P* = 0.229). However, the proportion of samples containing ground squirrels was weakly but significantly related to both actual northing and date (Figure 6).

Table 2. Incidence of prey items in resident badger scats and stomachs from the Rocky Mountain Trench, southeastern British Columbia, 1996 – 2004, based on prey skeletal analysis.

Prey	Samples Containing Prey Item (%)	
	North (n = 9)	South (n = 30)
Columbian ground squirrel	44	60
Chipmunk (*Tamia* spp.)	0	3
Possible red squirrel (*Tamiasciurus hudsonicus*)	0	3
Northern pocket gopher	0	3
Vole, possibly southern red-backed (*Clethrionomys gapperi*)	22[a]	0
Unidentified small mammal	0	7
Unidentified hair	11	10
Common loon (*Gavia immer*)	11[b]	0
Varied thrush (*Ixoreus naevius*)	0	3
Frog or toad	11	0
Long-toed salamander (*Ambystoma macrodactylum*)	0	3
Insect	33	13
No animal remains	22	20

[a] 2 badgers, 1 of which contained parts of at least 15 voles

[b] 1 badger, containing parts of at least 3 loons

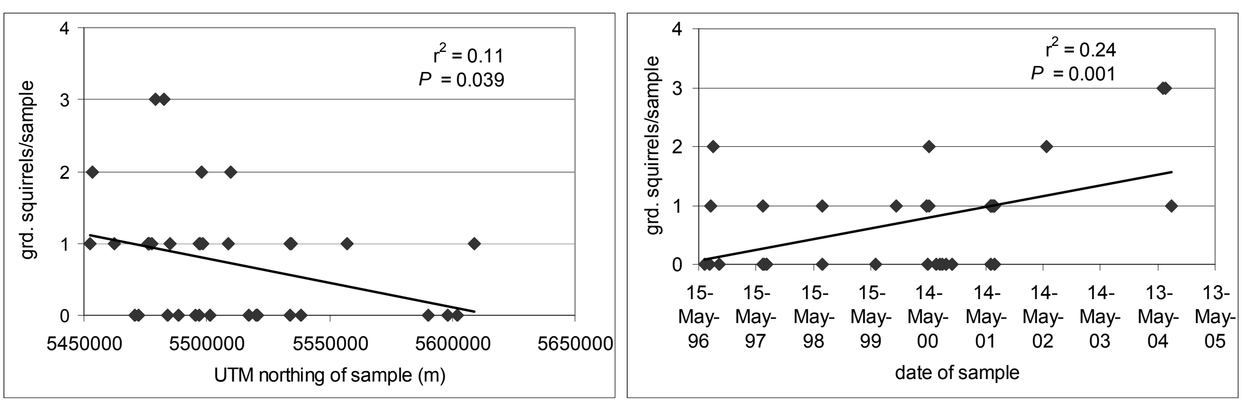

Figure 6. Effect of UTM northing and date on minimum number of ground squirrels per resident badger scat or stomach, Rocky Mountain Trench, southeastern British Columbia, 1996 - 2004.

Home ranges were generally larger for males than females, although there was high variability in the data (Table 3). Home range size was, in general, positively correlated to median UTM northing values (Figure 7) and negatively correlated to the median date at which data were collected (Figure 8).

Table 3. Home ranges among radiotagged resident badgers in northern and southern portions of the Rocky Mountain Trench, southeastern British Columbia, June 1996 – February 2006. Sample includes only animals with ≥ 25 locations across ≥ 1 year after an assumed first birthday of 15 April. *P*-values refer to t-test for differences between classes.

Area/Sex	n	100% Minimum Convex Polygon			95% Adaptive Kernel			95% Fixed Kernel		
		km^2	SE	*P*	km^2	SE	*P*	km^2	SE	*P*
North Male	3	653.9	106.7	0.032	184.6	80.4	0.318	99.0	49.3	0.466
North Female	2	78.6	7.6		78.9	12.9		54.8	8.0	
South Male	6	124.8	47.8	0.076	69.5	28.5	0.073	46.7	19.3	0.075
South Female	5	18.0	6.1		5.1	1.6		3.4	1.2	
Combined Areas Male	9	301.2	98.4	0.027	107.9	35.3	0.056	64.1	20.8	0.070
Combined Areas Female	7	35.3	12.1		26.1	13.9		18.1	9.7	

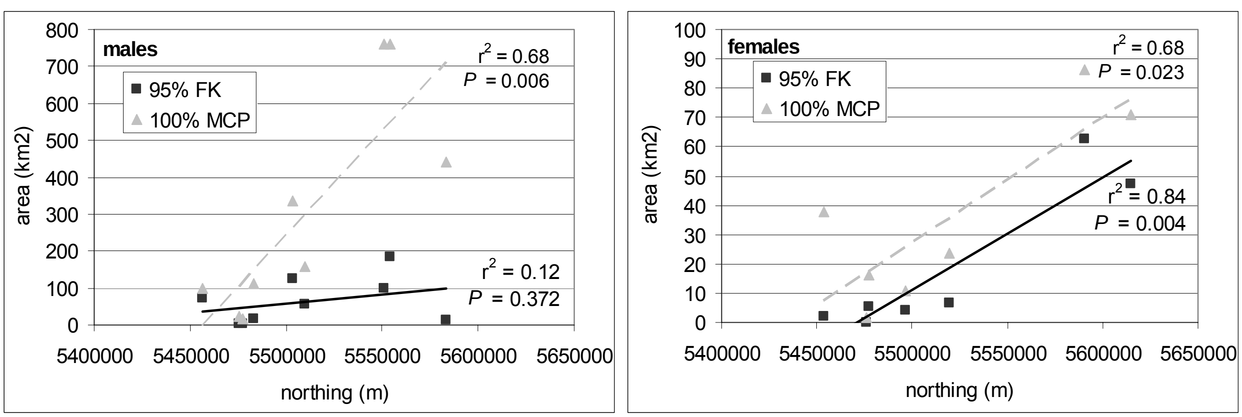

Figure 7. Resident badger home range size in relation to median UTM northing of telemetry locations, Rocky Mountain Trench, southeastern British Columbia, June 1996 – February 2006. Measures based on minimum convex polygon (MCP) and fixed-kernel (FK) estimators. Sample includes only animals with ≥ 25 locations across ≥ 1 year of monitoring after an assumed first birthday of 15 April.

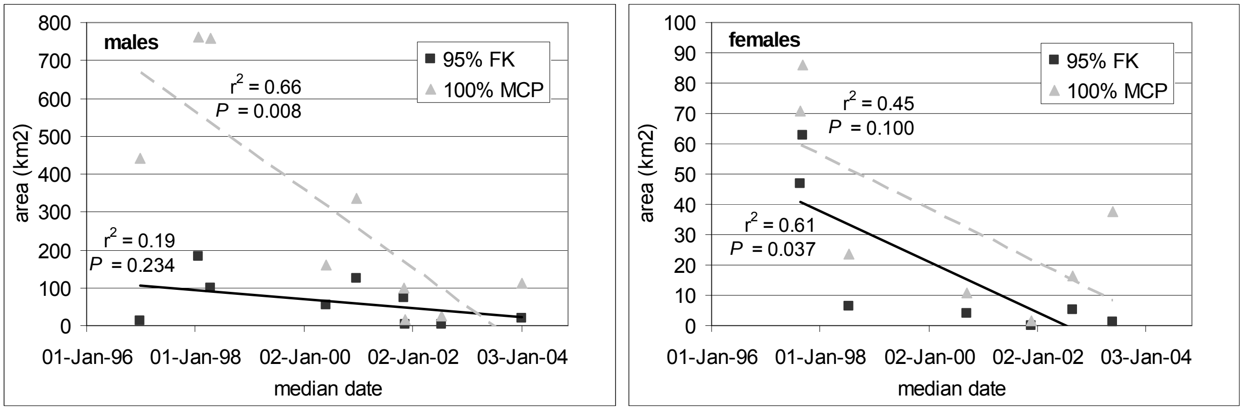

Figure 8. Resident badger home range size in relation to median date of telemetry locations, Rocky Mountain Trench, southeastern British Columbia, June 1996 – February 2006. Measures based on minimum convex polygon (MCP) and fixed-kernel (FK) estimators. Sample includes only animals with ≥ 25 locations across ≥ 1 year of monitoring after an assumed first birthday of 15 April.

Compared to females, resident male kits made initial dispersal movements later (325 vs 106 days, *P* = 0.010), made maximum dispersals later (495 vs 176 days, *P* = 0.002), and had greater maximum dispersal distances (26.1 vs 11.0 km, *P* = 0.035). Although males were also monitored for longer periods than females, there was little correlation between monitoring period and maximum dispersal for either sex (Figure 9), so this was unlikely to have significantly affected the observed patterns.

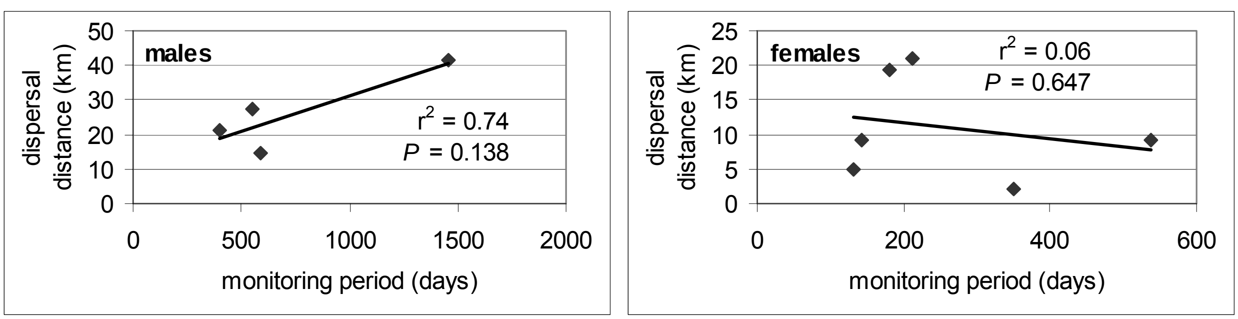

Figure 9. Effect on observed dispersal distance of monitoring period length after assumed birth date of 15 April for resident juvenile badgers, southeastern British Columbia, 1997 – 2002.

<u>Translocated Animals and Their Offspring</u>

We translocated 16 badgers from 2002 through 2004, including 8 adult males, 4 adult females, 2 juvenile males and 2 juvenile females. All were released within the northern portion of the study area, and radiolocations were entirely within the north, with the exception of 2 males having 3% and 23% of their locations in the south. We also radiotagged 6 juveniles (4 females, 2 males) that were the offspring of either translocated females or their kits, with all their radiolocations being in the north. However, animals lost from radio contact may have dispersed well beyond study area boundaries. We obtained 663 telemetry locations from translocated animals and their descendents.

Among adult females that were translocated or descended from translocated females, there were at least 10 kits from 5 successful litters across 8 animal-years of monitoring (n = 5 females including 3 > 1 year old). Of the 4 animals translocated as juveniles and the 6 radiotagged from the re-established northern population, 4 survived to their first birthday, 6 were lost from radio contact prior to that date (including all 4 translocated as juveniles), and none were known to have died, corresponding to a survivorship to age 1 of 100%. Sources of mortality for translocated adults included roadkills (3), probable predation (2) and probable roadkill (1). Based on the Kaplan-Meier (Figure 10) and Mayfield methods, annual translocated adult survivorship for males, females and combined sexes was 74/74%, 77/81%, and 77/77% respectively. Based on either the Kaplan-Meier or Mayfield survivorship estimates and assuming an even sex ratio, $\lambda = 1.39$. One badger translocated as a juvenile and lost from radio contact shortly thereafter was located over a year later in a garbage dump, with a functioning radioimplant. She likely died of human-related causes, but her date of death was unknown so she was initially excluded from analysis. However, if it is assumed that she died as a kit and was not detected until later, $\lambda = 1.27$; if she died as an adult shortly before being found, $\lambda = 1.33$.

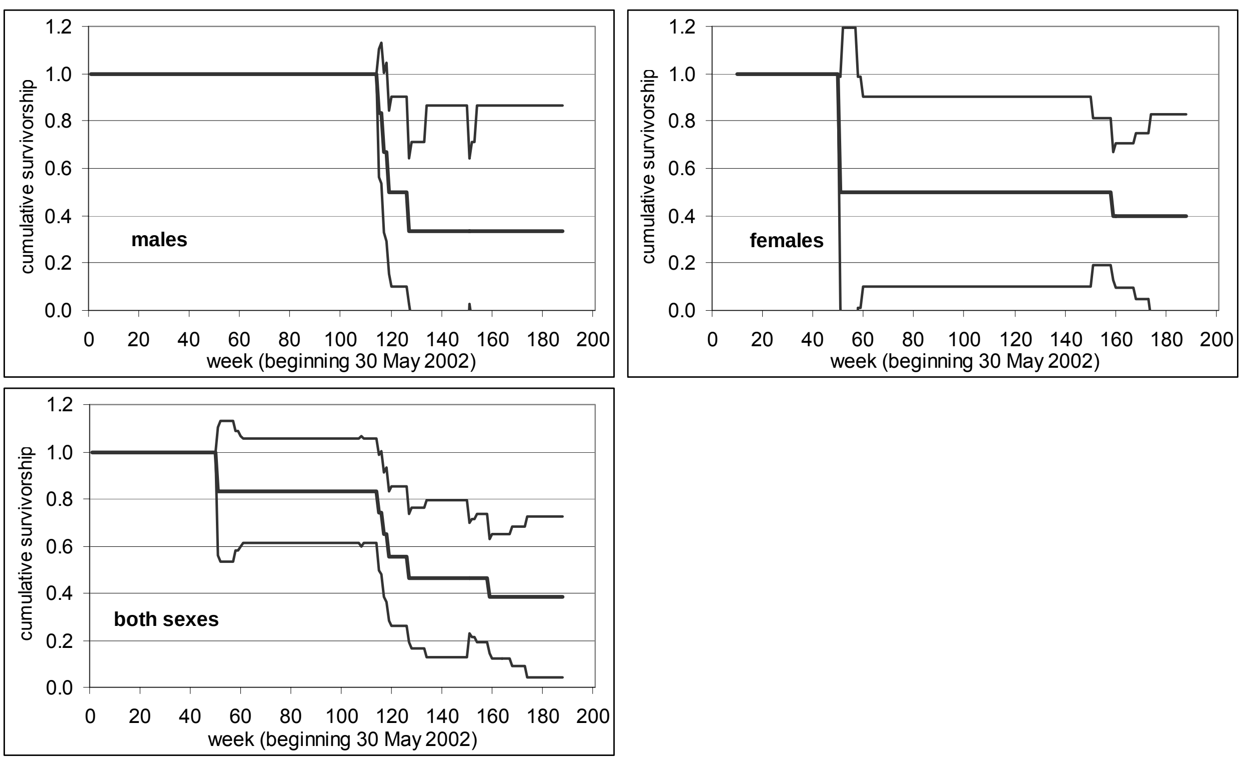

Figure 10. Kaplan-Meier survivorship (based on weekly intervals) and upper and lower 95% confidence intervals for adult badgers translocated to southeastern British Columbia from northwestern Montana, and the adult offspring of translocated badgers, May 2002 – February 2006.

Translocated badgers consumed a variety of prey, with 5 of 12 samples containing ground squirrels, 5 with unidentified small mammals, 1 each of red squirrel, possible red squirrel, *Microtus* spp. (most likely meadow vole, *M. pennsylvanicus*), and unidentified fish, and 2 containing no animal remains. The incidence of samples lacking prey remains did not differ between translocated animals and either northern or southern residents (*P* = 0.915, 0.804 respectively; Table 2), nor did the incidence of Columbian ground squirrels (*P* = 0.774, 0.281 respectively).

Home range sizes were generally much larger for males than females, though there was high variability relative to sample sizes (Table 4). Within the limitations of small samples, translocated female home ranges appeared to be smaller than those of northern residents (Table 3) and larger than but more similar to those of southern residents for each of 100% MCP, 95% ADK and 95% FK (t-test *P*-values of 0.067, 0.084 and 0.073 respectively in comparison to northern residents, and 0.358, 0.230 and 0.215 respectively in comparison to southern residents). Translocated male home ranges appeared larger than either northern or southern residents for each of 100% MCP, 95% ADK and 95% FK, though differences approached significance only in comparison to southern residents (t-test *P*-values of 0.832, 0.333 and 0.327 respectively in comparison to northern residents, and 0.048, 0.111 and 0.131 respectively in comparison to southern residents).

Table 4. Home ranges of adult badgers translocated to the Rocky Mountain Trench, southeastern British Columbia, 2002-2006.

Sex	n	100% MCP (km^2)		95% ADK (km^2)		95% FK (km^2)	
		Mean	SE	Mean	SE	Mean	SE
Male	4	702.0	185.2	343.2	123.4	193.9	71.9
Female	3	34.2	13.5	14.3	5.5	9.1	3.3
t-test *P*		0.036		0.076		0.082	

Six kits (n = 3 M, 3 F) born in the study area to translocated females were monitored to mean estimated ages of 397 days (+/-75 days SE). First dispersals of > 1 km from maternal dens occurred at a mean estimated age of 102 +/-4 days, with maximum dispersals at 255 +/- 66 days and mean distance of 32.4 +/- 10.7 km. No differences were detected between males and females for monitoring period, age at first or maximum dispersal, or maximum dispersal distance (t-test, *P* = 0.773, 0.590, 0.869 and 0.610 respectively). In comparison to female kits born to southern resident females, the female kits of translocated females did not differ in age at first or maximum dispersal, or maximum dispersal distance (t-test, *P* = 0.571, 0.636 and 0.230 respectively). For males, the corresponding *P*-values were 0.071, 0.118 and 0.999, with identical mean maximum dispersal distances between resident and translocated-offspring kits, but possibly earlier dispersal for translocated-offspring kits.

Discussion

Our results pointed to a declining resident badger population in the northern portion of our study area. All demographic, space-use and diet characteristics for badgers resident there were either similar to or more negative than those in the south, with no indication of reproduction in the north. In fact, prior to translocating badgers to the north, we had evidence of only 2 animals there other than those monitored, both of which were detected as roadkills (N. Newhouse, unpubl. data). This apparent local extirpation could be assumed to indicate that ecological or human-related conditions had deteriorated sufficiently in the north for it to have lost its ability to support badgers, perhaps permanently, while conditions in the south remained adequate to support a stable or growing population. However, consideration of that possibility must be tempered by the fact that research in the south was conducted later, such that demographic, space-use and diet characteristics varied in relation to date inversely to the way they related to latitude. This raises the alternate possibility that the relative ability of the Trench to support badgers varied temporally rather than, or in addition to, spatially. That is, a set of negative and possibly random events or conditions may have caused a temporary decline that was sufficiently strong to eliminate the northern population but not the larger southern population, followed by improving conditions that benefited the remaining southern population but not the now-extirpated northern population.

Translocating badgers to the north offered a means of testing whether the northern extirpation reflected a permanent loss of that area's ability to support badgers, or whether we more likely witnessed the effect of random events typical of small, range-limit populations. If the former was the case, recovery attempts in the north might be futile, especially if population augmentation was the tool used. If the latter possibility was true, recovery would likely be possible at least temporarily, particularly with the translocation of animals to initiate the process. The results of translocating badgers to the north following the apparent extirpation there, while spanning less than 4 years, were more consistent with the temporal-variation possibility. Despite the presumed hardships for animals moved to unfamiliar surroundings, translocated badgers and their descendents showed demographic, space-use and diet characteristics that were equivalent to or more positive than those of the original northern residents (and in some cases more positive than those of southern residents). Most significantly, the new northern population showed indications of growth. This should not have been the case had the observed differences among residents from north to south been due to a long-term loss of the north's ability to support badgers. In further support of there having been a temporary negative trend throughout the study area prior to or at the beginning of this study, there is some evidence that the growth apparent in the south had only recently begun. Mean resident home range sizes documented in the Rocky Mountain Trench as a whole were 2 to 150 times larger than any reported in the literature (Table 5). While ranges of females in the south (Table 3) were similar to those reported for Colorado and Illinois (Table 5), southern male home ranges were 4-7x larger than reported in those studies. If female home ranges are dictated mainly by food resources and males by the number of females, this suggests that there was a reasonable food supply but low female numbers, consistent with a lag in population growth following recently improved conditions. Also, the relatively late dates of dispersal for residents, as compared to dispersal at roughly 60 - 75 days and 70 - 120 days in 2 Idaho populations (Messick et al. 1981), are potentially indicative of habitat that was recently capable of providing adequate food for a mother and older kits within a small area over an extended period. This should have resulted in a large badger population and small home ranges for both sexes had it been the norm over the long term, so was more likely a more recent phenomenon. There was also a trend to higher survivorship later in the study for both the north and south. Thus, it is likely that much of the north-south variation reflected temporal rather than or in addition to spatial variability in key ecological or anthropogenic factors.

Table 5. Mean home ranges (km^2) of resident adult American badgers, southeastern British Columbia, 1996 – 2006, in relation to those reported in other studies, based on 100% minimum convex polygon (MCP), 95% adaptive kernel (ADK), and 95% fixed kernel methods.

Study Location	Source	Sample Size		100% MCP		95% ADK		95% FK	
		F	M	F	M	F	M	F	M
Idaho	Messick and Hornocker (1981)	7	3	2	2				
Wyoming	Goodrich and Buskirk (1998)	6	9			3	12		
Wyoming	Minta (1993)	15	18			3[a]	8[a]		
Colorado	Hoff (1998)	9	5			8	25		
Illinois	Warner and Ver Steeg (1995)	7	5	13	44				
South-central BC	Weir et al. (2003)	0[b]	5[b]		81				38
Southeastern BC	this study	7	9	35	301	26	108	18	64

[a] calculated as 95% harmonic mean contour

[b] based only on animals with ≥ 25 locations across ≥ 1 year

Potential explanations for the north and possibly the entire study having a declining population in the initial stages of the study yet an apparently growing population later on could be either stochastic or mechanistic. The Rocky Mountain Trench within our study area represents a “peninsula” of occupied badger habitat along the species’ northern limit. Within this, the northern Trench is narrower, includes the known limit, and is more isolated from other badger populations than is the southern Trench. As a result, the Trench and especially the northern part of it would be expected to support few animals and be prone to random events and natural population fluctuations, including temporary extirpations. Such fluctuations might be exacerbated by the Allee Effect, in which reproductive success often declines as populations drop. For example, if badgers are induced ovulators (Messick and Hornocker 1981) and males accompany each female only briefly, the reduced opportunities for repetitive mating at very low population densities should lead to lower pregnancy rates and further declines. From a more mechanistic perspective, there has been legal protection of Columbian ground squirrels on public land in the province only since 1992. The evidence of an increased incidence of ground squirrels in the diet of resident animals later in the study may have been related to that. Cougars potentially killed at least 2 tagged badgers, and appear to have declined significantly across southeastern British Columbia from the beginning to end of this study as evidenced by annual number of problem-animal and other non-hunter kills of that species (Ministry of Environment, Cranbrook, British Columbia, unpubl. data). It is also possible that the public outreach accompanying this research resulted in fewer intentional killings by landowners, though there are no data to support this.

Our results point to the value of long-term monitoring of populations of badgers or other species at range limits, or endangered populations generally. If trends relating to persistence vary dramatically over time, then short-term observations indicating that certain areas have lost their ability to support a species may be misleading. Population augmentation provides a test of whether long-term, deterministic factors have made a given area unsuitable, or whether observed losses are the result of short-term fluctuations. In the event that the latter is true, augmentation through translocation or other means also provides a means of initiating recovery. In the case of badgers in the northern part of the Rocky Mountain Trench, the translocation of wild-caught animals has succeeded in establishing a population that is small but apparently growing 3.5 years after release. However, long-term monitoring will be essential as there is no indication of improvement among several factors potentially contributing to initial negative trends, such as highway traffic volumes, housing development and forest ingrowth.

Management Recommendations

We offer four observations relating to the use of translocation:

1. The loss of a species-at-risk from a locale should not necessarily be taken as evidence that the area can no longer support that species. Fluctuations in any population's size are more likely to cause extirpation when numbers are low, so the simple addition of more animals, along with potentially modest improvements in ecological conditions, may be sufficient to initiate recovery or at least improve stability. Where there is a nearby source population having no at-risk status, translocation provides a low-risk experiment and potentially speeds recovery.
2. Part of the initial success may have been due to translocations occurring shortly after the loss of the original resident population. Burrows in which badgers are found are more often re-used than freshly dug (N. Newhouse, unpubl. data), so translocating animals prior to those burrows deteriorating was likely beneficial. From a social perspective, having a collective public memory and recognition of badgers as part of the ecosystem probably improves the likelihood of support for both translocation and the necessary management actions (such as habitat restoration, protection of prey, and

improving the public's perception of the value of badgers). In fact, rather than viewing translocation as being appropriate only when land and resource management actions have already been taken to maximize the likelihood of success, we argue that the re-introduction of an endangered species through translocation in itself acts as a catalyst for appropriate management activities.

3. For translocated badgers, the slightly lower survivorship among males, due largely to roadkills which in turn were likely due to more extensive movements, indicates that a preponderance of that sex might be desirable. This imbalance would presumably help ensure pregnancy among translocated females and therefore increase litter size, given the polygamous mating pattern. In addition, it would decrease the likelihood of females competing with other females for food in the initial period after translocation, likely furthering site fidelity and kit production. This pattern may hold for other carnivores with similar space-use patterns.
4. Preliminary indications are that the translocation of kits (family groups) had no significant benefit. We had initially expected that juveniles might be less attached than adults to their point of origin, making them less likely to "go home". However, preliminary indications are that translocated kits did not remain near release sites or mothers and in fact were rapidly lost from radio contact, whereas females and offspring born in future years showed site fidelity. While means of improving the fidelity of translocated juveniles to their release sites may be found, conservation goals might ultimately be best served by leaving independent juveniles in the source area. This would facilitate them establishing home ranges in areas vacated by captured animals, thus improving the status of the source population and allowing future removal of animals for translocation.

Acknowledgements

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Chapter 2.
Communications Update

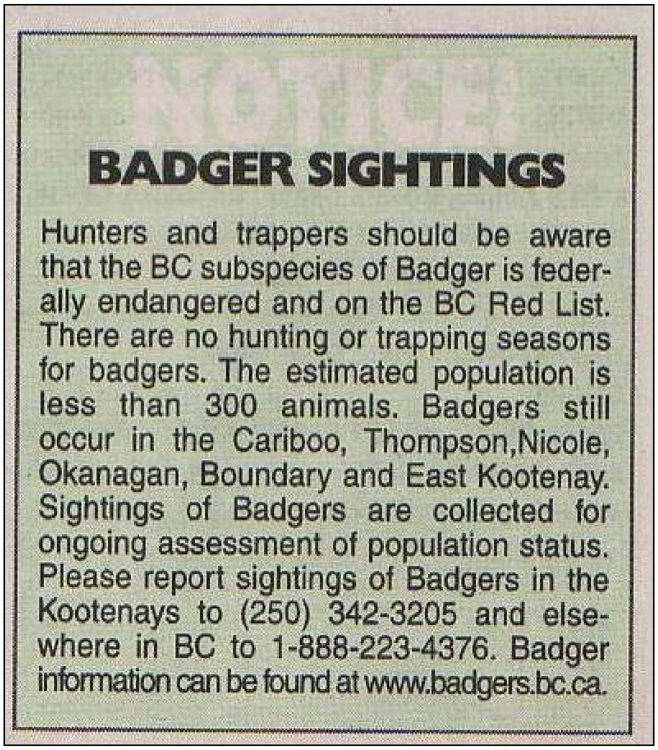
Introduction

Badgers are red-listed in British Columbia, and BC's subspecies (*Taxidea taxus jeffersonii*) is listed as endangered by COSEWIC. An intensive research and conservation project, the East Kootenay Badger Project (EKBP), has been underway in the southeastern British Columbia since 1995 (Chapter 1). The East Kootenay Badger Project takes a multi-pronged approach to conserving badgers, including public education, conservation covenants, highway design recommendations, input into habitat enhancement, assessment of reproductive success and mortality factors, DNA research, and implementation of population augmentation. The project is an international partnership of both private and public organizations, and has included support and participation of Parks Canada, the Columbia Basin Fish and Wildlife Compensation Program, Tembec Industries, Montana Fish, Wildlife and Parks, Wildsight, the Land Conservancy of BC, the BC Ministry of Environment; the BC Ministry of Forests and Range, and the ?Akisq'nuk First Nation.

Under the guidance of the national *jeffersonii* Badger Recovery Team, conservation messages have been delivered through multiple media ranging from one-on-one meetings and phone calls with landowners to TV productions, websites, displays, radio, newspapers and scientific publications. Those used in the past year are described below.

Badger Hotline

The toll-free reporting line for badger sightings (1-866-EK-BADGER) was maintained in 2005/06. The hotline served both as a tool to receive information about badger locations and as a valuable opportunity for researchers to convey ecological and conservation messages to callers. The hotline was publicized on websites, postcards, popular media and in the *British Columbia 2005/06 Hunting and Trapping Regulations* (Figure 2.1).



NOTICE!

BADGER SIGHTINGS

Hunters and trappers should be aware that the BC subspecies of Badger is federally endangered and on the BC Red List. There are no hunting or trapping seasons for badgers. The estimated population is less than 300 animals. Badgers still occur in the Cariboo, Thompson,Nicole, Okanagan, Boundary and East Kootenay. Sightings of Badgers are collected for ongoing assessment of population status. Please report sightings of Badgers in the Kootenays to (250) 342-3205 and elsewhere in BC to 1-888-223-4376. Badger information can be found at www.badgers.bc.ca.

Figure 2-1. Badger sightings notice from *BC Hunting and Trapping Regulations 2005/06*.

Websites

There are several active websites that provide information about the EKBP, including:

- Columbia Basin Fish and Wildlife Compensation Program (www.cbfishwildlife.org)
- Parks Canada (www.pc.gc.ca/pn-np/bc/kootenay/natcul/natcul30a_e.asp)
- jeffersonii Badger Recovery Team (www.badgers.bc.ca)
- Science World British Columbia (www.scienceworld.ca/whats_on/science_theatre/now_playing/badgers.htm)
- Nature Conservancy of Canada (www.natureconservancy.ca/pdf/ark_fall05_english.pdf) (http://www.natureconservancy.ca/pdf/NCC_AR_EN_Final.pdf)
- Denise Withers (producer of Champions of the Wild badger documentary) http://homepage.mac.com/denisewithers/iblog/StorySharing/C376604327/

Display at Radium Hot Springs Visitor Centre

A new Parks Canada display focusing on the use of fire as a tool for eco-restoration has been installed at the Radium Hot Springs Visitor Centre. The display includes a painting of a badger, based on a photo by Tim McAllister (Figure 2.2). The display was installed in May, 2005 and the centre received about 19,000 visitors from May to December, 2005.

Figure 2-2. Badger drawing as part of ecosystem restoration display at Radium Hot Springs Visitor Centre.

Presentations

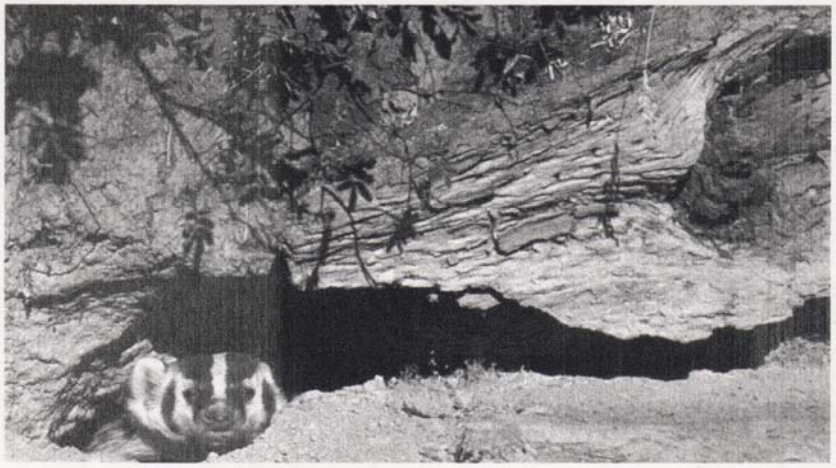
During the 2005-2006 year, presentations on the research results and conservation implications of the EKBP were made to 28 students at J. A. Laird Elementary School, Invermere, BC and 32 participants at the "Species at Risk in K'tunaxa Traditional Territory" workshop, Cranbrook, BC (Figure 2.3). Updated research results were also presented to the *jeffersonii* Badger Recovery Team. In addition, Parks Canada interpreters presented 19 theatre productions about badger ecology and conservation in Kootenay National Park.

Figure 2-3. Poster for workshop attended by project biologist.

Television, Science World, Brochures, Books and Burrow ID Card

Education efforts continued in 2006 through television, brochures, newsletters, and a new burrow ID card. Highlights included several re-broadcasts of the "Champions of the Wild" documentary on the Knowledge Network and a showing of it twice per day at the Science Theatre at Science World in Vancouver, BC from November, 2005 through March, 2006. Parks Canada highlighted the Science World showing of the Champions of the Wild documentary in the January 24, 2006 "Faces and Places" email, which is distributed from Kootenay National Park to about 500 people. The Nature Conservancy of Canada included an article on grassland conservation and badger research in the NCC Annual Report 2005 (Figure 2.4) and highlighted badger as the feature species for the fall, 2005 version of The Ark (Figure 2.5). Parks Canada selected the East Kootenay Badger Project for its 2005 publication "Action on the Ground – Ecological Integrity in Canada's National Parks" (Figure 2.6). We cooperated with The Land Conservancy of BC's "Adopt a Badger" program, a fund-raising program to purchase properties in the Wycliffe area, by supplying project brochures for mail-outs to 60 donors. In the spring of 2005, TLC completed the purchase of the final phase of the Wycliffe Wildlife Corridor, bringing the size of protected area for badgers to over 350 ha. We also provided badger photos for inclusion in the new "BC Experience at the Crystal Palace" (http://www.bcexperience.info/).

In addition, a burrow ID card was developed (Figure 2.7). The card will be a tool for field technicians and private landowners to differentiate between badger, ground squirrel, and coyote burrows. The material will also be posted on the BC Badger website.



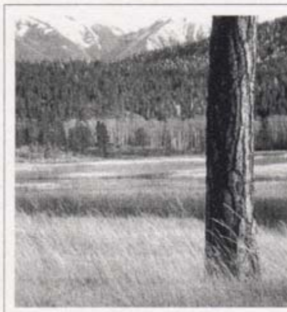
BRITISH COLUMBIA'S ROCKY MOUNTAIN TRENCH

NORTH AMERICAN BADGER (*JEFFERSONII* SUBSPECIES) IS LISTED AS ENDANGERED LARGELY DUE TO HUMAN IMPACTS ON HABITAT AND POPULATIONS; PHOTO BY TIM ENNIS

Providing Room to Roam

DRY GRASSLANDS don't immediately spring to mind for most people when thinking about British Columbia's natural areas. Yet the province is home to a dramatic diversity of these ecosystems, which are the most endangered in the province.

Naturally restricted to only about 1% of the province's land base, BC's grasslands occur primarily in dry areas on the lee side of major mountain ranges. These incredibly scenic and rare landscapes are faced with a number of threats including conversion to cropland, urban expansion and the introduction of non-native invasive species. As a result, BC's disappearing grasslands are home to more endangered species than any other habitat type in the province including North American Badger, Long-billed Curlew, Spotted Bat, Gopher Snake, and Golden Paintbrush.



NCC is spearheading efforts to identify the most strategic places to conserve grasslands in BC through our Ecoregional Planning program. The results of this program provide NCC and other groups with a roadmap of where to concentrate our conservation efforts.

Identified as a high-priority area is the Upper Columbia River Valley in the Rocky Mountain Trench. In the summer of 2004, NCC advanced BC grassland conservation here significantly with the protection of the 3,100-acre Kootenay River Ranch. Although it has been used for cattle grazing, the grassland has not been broken and the property does not have any buildings on it. It stretches parallel for seven kilometres to the Kootenay River on the east side of the property and exceeds 1.25 kilometres at its widest point. Interspersed with pocket wetlands, small lakes and riparian shrub habitat, Douglas Fir, Ponderosa Pine, Western Larch, and Aspen dominate the open forest that towers over the Rough Fescue, Junegrass, Bluebunch Wheatgrass, and Antelope Brush in the understorey. The Kootenay River Ranch has been an important study area for wildlife biologists Trevor Kinley and Nancy Newhouse whose research has confirmed the presence of endangered Badger on the property, along with invaluable feeding and nesting areas for migratory and resident waterfowl.

Over the coming years, NCC's stewardship and restoration work will ensure the continued existence and enhancement of this important, unbroken jewel of a BC grassland site.

Figure 2-4. Article from the Nature Conservancy of Canada's Annual Report 2005.

FEATURED SPECIES

THE NORTH AMERICAN BADGER

The North American Badger (*Taxidea taxus*) is a heavy-bodied, short-legged and short-tailed member of the weasel family. Its main food is the Columbian Ground Squirrel, but badgers will also eat other small mammals, birds, fish and insects. The Badger's powerful front legs and long claws are used to dig out prey. The claws are not used in defense. Its muscular neck and thick, loose fur protect it when an animal predator strikes.

The Badger can use hundreds of burrows in its home range. It uses them for sleeping, hunting, storing food and giving birth. A Badger may change dens every day, except when it has young. Badger dens have one entrance with a pile of dirt next to it. When the animal is threatened by predators, it will often back into a burrow and bare its teeth. It may then plug up the burrow's entrance.

Unfortunately, animal predators aren't the biggest threat to the Badger. Two subspecies – those in British Columbia (*jeffersonii*) and Ontario (*jacksoni*) – are now listed as endangered largely due to human impacts on their habitat and populations. Habitat loss through urban development, intensive agriculture and forest in-growth, coupled with direct loss of animals through shooting, trapping and roadkills has reduced badger populations. The *jeffersonii* subspecies makes its home in the dry interior of southern British Columbia; places like the Rocky Mountain Trench. In BC, scientists estimate there are about 300 adult badgers left.

In the summer of 2004, NCC advanced BC grassland conservation in the Rocky Mountain Trench with the protection of the 3,100-acre Kootenay River Ranch. Although it has been used for cattle grazing and hay production, the grassland has not been broken up by roads and the property does not have any buildings on it. It stretches parallel and unbroken along seven kilometres of the Kootenay River on the east side of the property and exceeds 1.25 kilometres at its widest point. The Kootenay River Ranch has been an important study area for wildlife biologists Trevor Kinley and Nancy Newhouse whose research has confirmed the presence of endangered *jeffersonii* Badger on the property, along with feeding and nesting areas for migratory and resident waterfowl.

With the protection of additional *jeffersonii* Badger habitat in the dry, grassland interior of British Columbia, NCC hopes to contribute to the survival of this mammal.

TAXIDEA TAXUS JEFFERSONII; PHOTO BY TIM ENNIS.

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Figure 2-5. Article from the Nature Conservancy of Canada's "The Ark", Fall 2005.

Ensuring badgers remain a vital part of the East Kootenays is the aim of an international, public-private sector partnership

Local landowners and Kootenay National Park of Canada help conserve the endangered badger as well as rare grassland habitat

Four subspecies of American badger occur in North America. In Canada, the endangered *Taxidea taxus jeffersonii* lives only in British Columbia's dry interior, such as the Columbia Valley at the southern end of Kootenay National Park. Despite having few natural predators, British Columbia badger numbers are in decline because of loss of habitat, a decrease in prey species, and death caused directly by human activities. There are fewer than 350 remaining adults.

Badgers live in grasslands, shrub-steppe habitats or open-canopied forests of Ponderosa pine or Douglas fir that supply the right soil for burrowing and enough small mammals to prey on. The only carnivore that burrows after and eats other tunnelling animals, the badger is a key predator of ground squirrels, mice and voles. Badgers play an important role in grasslands ecosystems. When badgers dig to pursue prey or to excavate a burrow, they improve soil conditions for various plants. In addition, their large burrows provide shelter for other wildlife, such as Burrowing owls and snakes.

Initiated in 1995 with the participation of Parks Canada, the East Kootenay Badger Reintroduction and Threat Mitigation Project is a collective effort to improve and restore badger populations in the region. The project, supported by the Species at Risk Recovery Fund, includes Canada's first intensive radio telemetry-based long-term study of badger ecology and distribution. For the research phase of the project, badgers are live-trapped and implanted with a radio transmitter. They are then returned to their burrows and can be tracked using a radio-telemetry receiver. Researchers assess badger population trends, habitat needs and the effects of human activities.

Since 2002, in cooperation with United States-based researchers, 16 badgers have been moved (or translocated) from northwestern Montana to the East Kootenays' upper Columbia Valley to "kick-start" the recovery phase of the Columbia Valley badger population. Research has shown that the key to conserving these animals is stewardship on private land. Along with their many partners, Parks Canada staff, summer students and volunteers are working with the public to promote practices that will protect the badger and its habitat within and across park boundaries.

Figure 2-6. Article from "Action on the Ground" book, Parks Canada, 2005 (continued on next page).

Results

- The project is Canada's first intensive radio telemetry-based study of badger ecology and distribution.
- Thirty-two badgers from Radium Hot Springs to Cranbrook have been implanted with radio transmitters to determine: movement rates and home range size; patterns of habitat use and dispersal; birth rates and reproductive success; and causes of death.
- Of the 16 badgers translocated from Montana to the south end of the East Kootenays, all three translocated females successfully reproduced in 2004, adding eight kits to the population.
- Radio-tagged badgers have been shown to use culverts to cross highways. Parks Canada and the British Columbia Ministry of Transportation built the first badger tunnel in the province. Badger crossing signs were installed elsewhere to encourage drivers to slow down in badger habitat.
- Project biologists work closely with golf course managers, highway designers, private landowners and conservation organizations to encourage stewardship practices for the recovery of badgers and their prey, ground squirrels.

© Richard Klafki

Figure 2-6. Article from “Action on the Ground” book, Parks Canada, 2005 (continued from previous page).

Badger Burrow ID

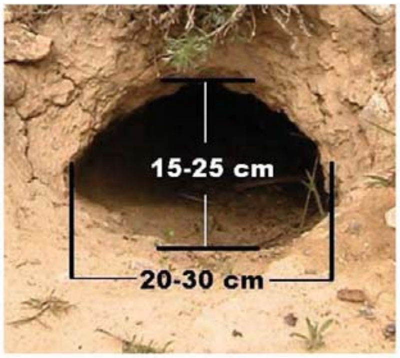
OCCURRENCE
- southern interior of BC
- variety of habitats; grasslands and dry open forests are most common
- occur in logged or burned forests, often at disturbed areas such as landings
- also occur in the alpine

SIGN
- mound of dirt at the entrance to a large elliptical hole
- burrow plugged with soft "fluffy" dirt is good indication the badger is currently in the burrow
- badgers regularly re-use burrows across their range

BURROW LOCATION
- flat to steep terrain from valley bottom to alpine
- silty, loamy, clayey and sandy; coarse fragments range from low to high

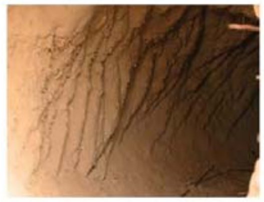
DIET
- main source: Columbian ground squirrel
- other sources: voles, marmots, muskrats, birds, insects and scavenged roadkill

Figure 2-7. Badger burrow ID card developed in 2006/06 (continued on next page).



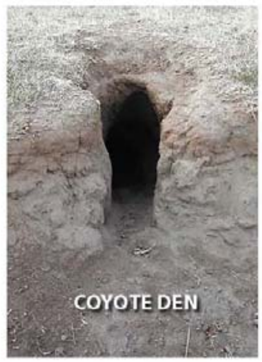
BADGER BURROWS

- elliptical shape; about 20–30 cm wide and 15–25 cm high
- claw marks may be seen along sides and top, 3–5 cm apart



TRADING PLACES

- foxes, coyotes and bears often enlarge and use an old badger burrow
- coyote dens are taller and less round
- badgers and ground squirrels regularly "exchange" burrows
- burrows most recently occupied by ground squirrels often narrow down to 10 cm
- burrows used by badgers most recently remain at least 19 cm wide



GROUND SQUIRREL BURROWS

- fairly round, with entrances about 10 cm in diameter
- amount of dirt at the entrance of badger or ground squirrel burrows highly variable and not a good indicator of which species excavated the burrow

jeffersonii Badger Recovery Team

Photo credits: Tim McAllister, Richard Klafki, and Roger Packham

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Figure 2-7. Badger burrow ID card developed in 2006/06 (continued from previous page).

Chapter 3.
Badger Sightings Reported by the Public

Sightings were collected through the toll-free line for reporting badger sightings (1-866-EK-BADGER; Chapter 2) and through informal communications with the public and resource-management professionals. Many of the sightings this year were reported in response to a notice in the hunting regulations (Chapter 2). Our target area for sightings was the East Kootenay, i.e. the area between the heights-of-land of the Purcell and Rocky mountains, including the Rocky Mountain Trench, from the Montana border to the northern tip of the Purcells. However, we also received reports from the West Kootenay and Boundary areas. Sightings recorded here include only those from the East Kootenay and the west slope of the Purcell Mountains (Figure 3.1).

From March 2005 through March 2006 we recorded 165 additional sightings, of which 13 were observations made prior to 2005. This brings the total number of sightings to 1027 since 1996 (Figure 3.1). Of the 152 sightings made in the past year, 123 were of live badgers, 7 were of roadkilled badgers, 2 were of badgers dead from other causes, and 20 were of fresh diggings. Considering all records collected since the inception of this project, badger sightings have been concentrated in the major low-elevation valleys, particularly the Rocky Mountain Trench. However, there were scattered locations at higher elevations with single to many sightings, extending well into the Purcell and Rocky mountains. Sighting locations were no doubt biased to areas with greater numbers of people and along transportation corridors.

It is not known how many of the sightings represented repeat observations of the same individuals. However, for sightings of family groups, we assumed that any made within 2 km of each other represented the same groups (this is the same criterion used in past years). On that basis, 10 family groups were reported in the East Kootenay in the summer of 2005 (Figure 3.2). We were aware of 1 additional litter, determined through radiotelemetry (Chapter 1), which was not reported. Family groups were reported in 2005 from the Fernie, Wardner, Bull River, McGinty Lake, Wycliffe, Cranbrook to Moyie, Sunrise Creek and Hawkins Creek areas.

The 7 records of non-tagged roadkilled badgers during 2005/06 bring the total of non-tagged badgers reported as roadkills since 1996 to 41 (Figure 3.3). In addition, 2 tagged badgers whose transmitters had failed were reported to us as roadkills in previous years. For this analysis, we consider them to be essentially non-tagged, since we were only aware of their status via sightings. Roadkills occurred throughout the study area from Edgewater south, but were concentrated on Highway 95A between Kimberley and Cranbrook, Highway 3 from Cranbrook to Elko, and on Highway 43 north of Sparwood (Figure 3.1). Kills occurred in every month from April to November, with peak rates from June through

August (Figure 3.4). None were reported during the winter. Of the 26 non-tagged animals for which the carcass was recovered from 1996 to 2004, 14 were males and 12 were females. Ages of 16 of these roadkilled animals were determined in the same way as for radiotagged animals (Chapter 1) and indicated both young and very old animals (Figure 3.5). However, the juvenile and 1-year-old cohorts, normally the most common in any population, were underrepresented as roadkills.

We examined the extent to which observations made by the public matched data from radiotagged badgers, to indicate whether sightings records could be used as a surrogate for radiotelemetry research. Habitat-based comparisons of tagged and non-tagged animals are summarized in Chapter 4. The mean number of kits reported per litter by the public (2.0, Figure 3.2) was slightly larger than that among resident and translocated females with successful litters (1.7; Chapter 1). This may be due in part to the decreased likelihood of a female with a single kit being seen (relative to a larger number animals) but is no doubt due in part to the assumption that badgers observed to be alone are adults, especially since the size difference between kits and adults is not readily apparent by mid-summer. The temporal distribution of reported roadkills within the year approximated that of radiotagged animals (Figure 3.4). However, comparing years in which tagged versus non-tagged badgers were roadkilled does not provide a reliable comparison, as this is heavily influenced by the influx of translocated badgers in certain years (those animals had high roadkill rates) and because the sample of tagged animals did not remain constant or proportional. Similarly, the sample of only 4 resident badgers that were roadkilled provides little basis with which to examine ages. Considering only the sightings data, there was no strong consistency among years between the number of roadkills and the number of kits ($R^2 = 0.35$) or litters ($R^2 = 0.45$) reported. Similarly, the number of reported litters per reported roadkill was 1.7 compared to 2.8 for radiotagged badgers, and the number of reported kits per reported roadkill was 3.3 compared to 4.8 among radiotagged badgers. This suggests that roadkilled badgers are, as would be expected, highly visible to the public and/or more likely to be reported than are litters of live badgers, so the relationship between roadkill numbers and kit production differs between sightings and telemetry data. In sum, roadkills reported by the public are not detectably biased with regard to month of kill, but provide only a crude predictor of demographic trends. This suggests that any use of roadkill data reported by the public in future years or other locations to evaluate badger demographics must be done cautiously.

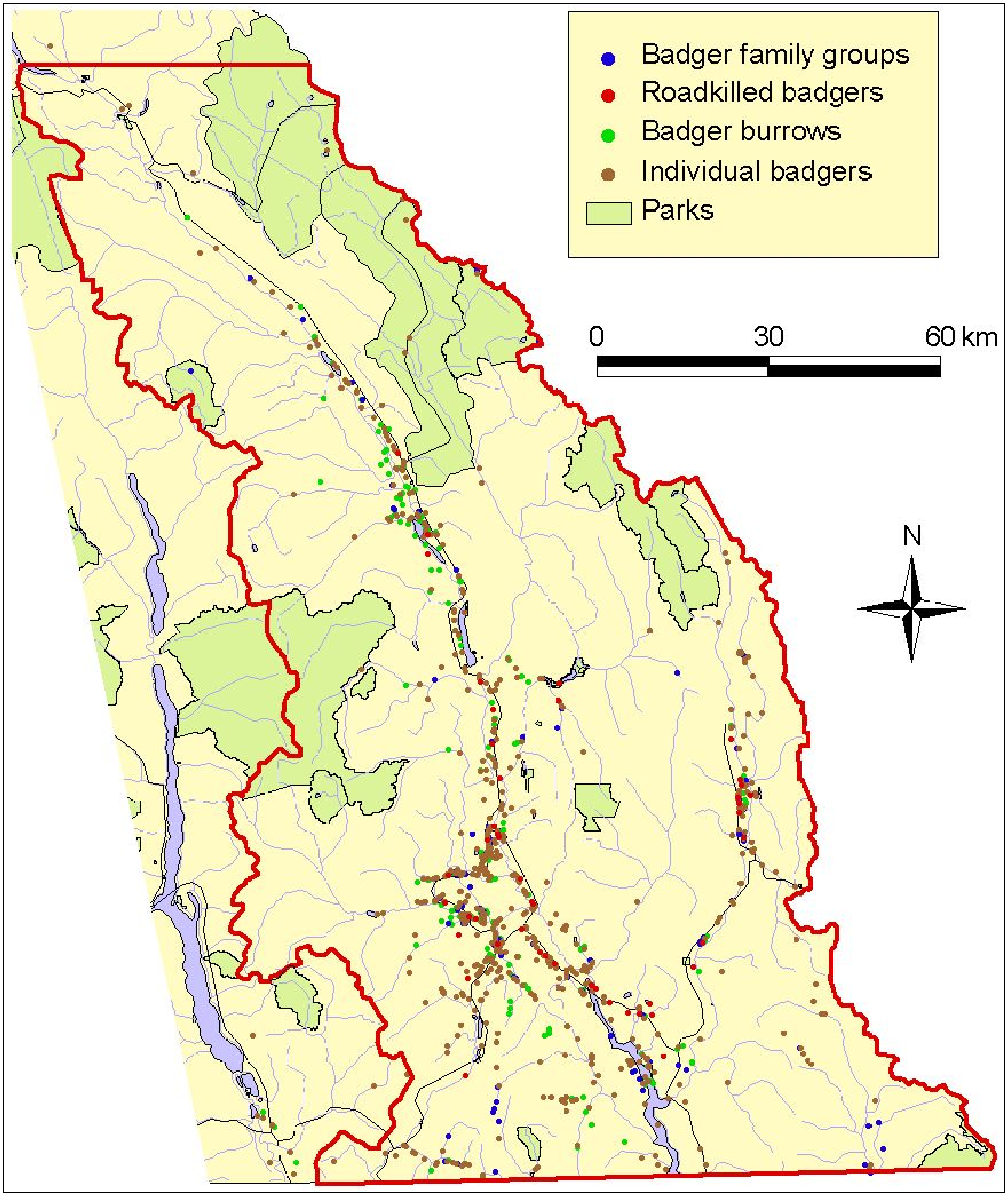

Figure 3-1. Locations of badger sightings reported by the public within the East Kootenay region (red line) and west slope of Purcell Mountains to March, 2006.

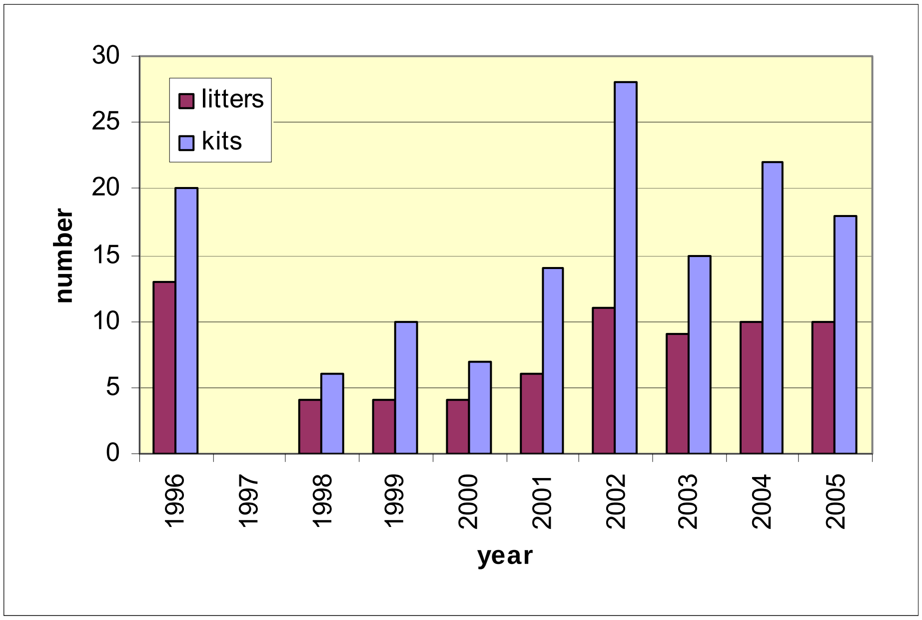

Figure 3-2. Number of non-tagged badger litters (n = 71) and kits (n = 140) reported in the East Kootenay, 1996 to 2005.

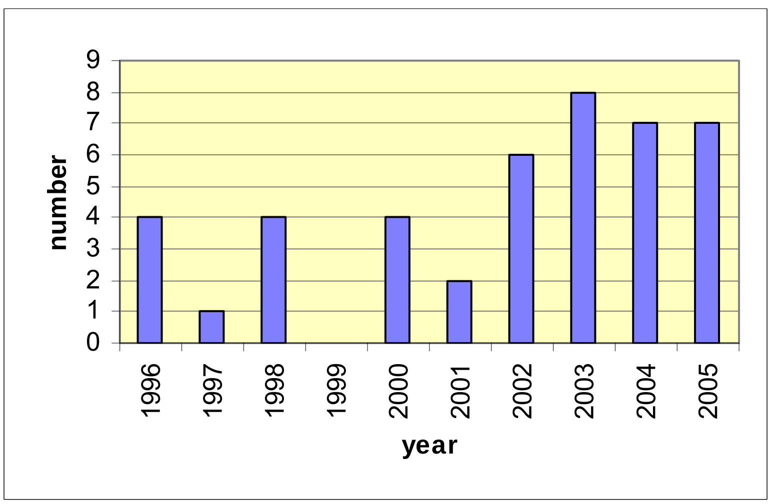

Figure 3-3. Number of non-tagged roadkilled badgers reported in the East Kootenay, 1996 to 2005 (n = 43, including 2 tagged animals with failed transmitters located through reports from the public).

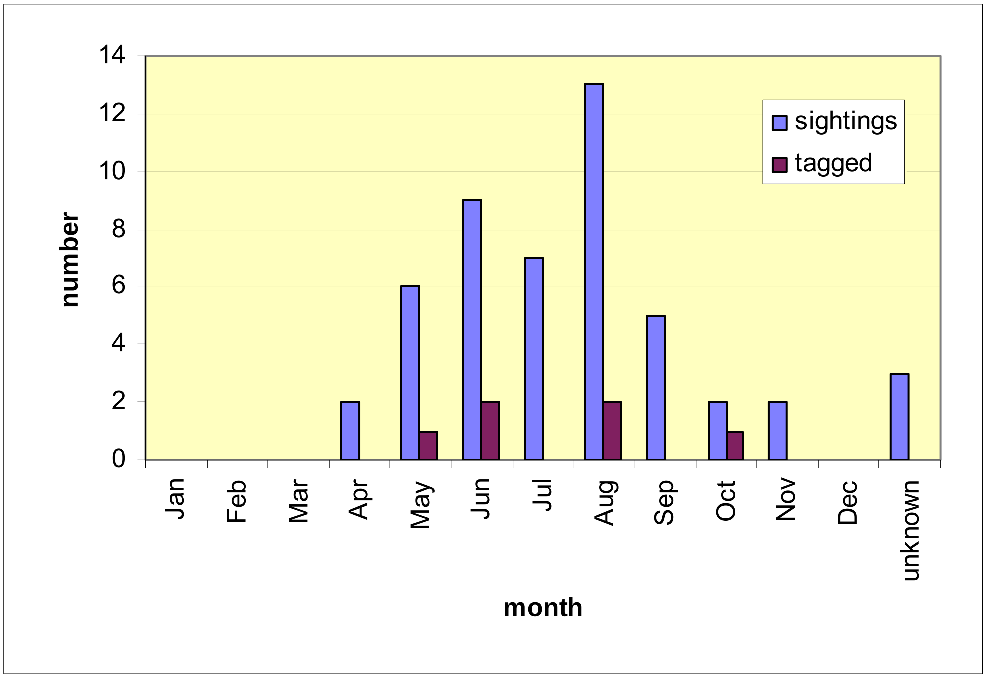

Figure 3-4. Timing of roadkills reported by public (n = 43) and among radiotagged badgers (n = 6) in the East Kootenay, 1996 to 2005. Two tagged badgers with failed transmitters are included in sightings rather than tagged sample as their status would be unknown except for the sighting).

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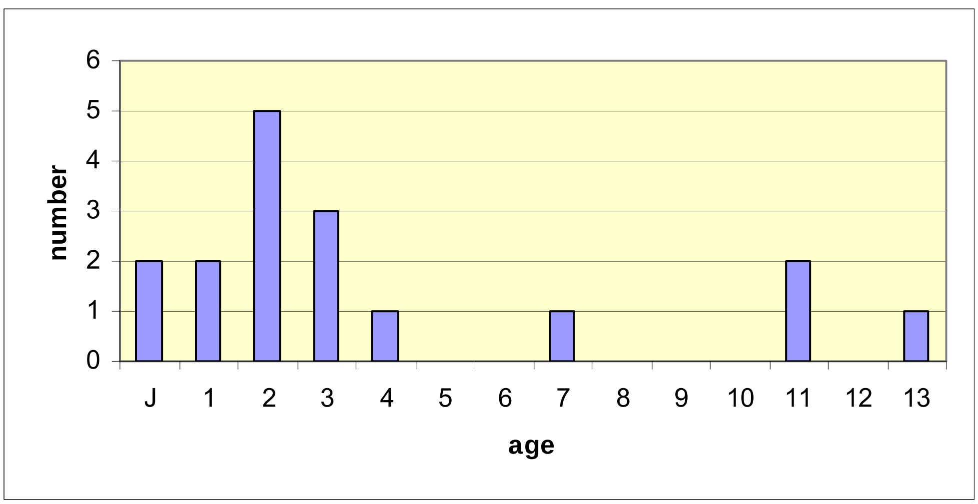

Figure 3-5. Ages of roadkilled badgers reported by the public for which a tooth was available in the East Kootenay, 1996 to 2005 (n = 16, including 2 tagged animals with failed transmitters located through reports from the public).

Chapter 4.
Preliminary Analysis of Habitat Attributes at Badger Radiotelemetry and Sightings Locations

Abstract

We extracted habitat attributes for radiolocations and also sightings of badgers or badger sign reported by the public. Both datasets showed the use of a wide variety of environmental conditions, but showed a concentration of activity at low elevations, particularly within the IDF, PP and to a lesser extent the MS in the East Kootenay Trench. Surficial materials that were excessively coarse or fine were used little. Pasture and rangeland supported the majority of activity, but recently logged areas and young forest were also heavily used, particularly in locations where climax stands were of drier forest types dominated especially by Douglas-fir. Somewhat surprisingly, given our understanding of badgers as being associated with open areas, there was considerable use of mature forest stands (e.g. 60-120 years), including those with relatively high crown closures and site indices, and of several ecosections dominated by forest. Badgers also commonly occurred along roadsides and in other developed areas, with about 1 in 6 radiolocations falling within 50 m of a road. Differences between the sightings and telemetry datasets appeared to relate largely to the sightings being more heavily concentrated near roads and in other areas with a human presence, but are also due to many sightings occurring in ecosystems beyond the bounds of the telemetry study area. In applying this data for future habitat evaluations locally or in conducting similar analyses in other regions, the value of having telemetry data (collected in a consistent fashion, with known levels of independence and without a roadside bias) must be weighed against the broader geographic and ecological representation offered by sightings. One possible approach would be to compare sightings to telemetry data only within ecosections or biogeoclimatic zones from which telemetry data had been obtained, to minimize the confounding effects of differing landscapes. This stratified approach would more clearly demonstrate whether the two data sources provided different results and if so whether the differences could be minimized by considering characteristics within larger landscapes surrounding each record, rather than individual pixels. If differences were minimal, the sightings and telemetry datasets could potentially be combined within those ecosections or zones. A lack of difference within that stratum would also suggest that sightings were representative of badger activity in general and sightings could thus be used as the sole basis for habitat assessments in ecosections or zones where telemetry data was not available. As with any analysis based on GIS mapping, several cautions apply in the use of potential habitat variables. Micro-habitat features are not mapped, single map polygons may include multiple habitat classes, mapping is often incomplete or inconsistent, various map layers apply similar terms to different concepts, some map layers describe climax stand conditions but stands are often not in that state, mapping describing current conditions may not chronologically match the timing of animal records, and location error may produce some spurious results.

Introduction

Apps et al. (2002) conducted two-scale habitat modeling using data from the East Kootenay Badger Project. The model's spatial output has since been used in land-use planning, prioritizing habitat restoration work, and determining release sites for translocated badgers, but several limitations to the model's utility are apparent. The model covered just a portion of the project study area, was based on only 12 animals and spanned 5 years. Data is now available from 56 badgers that were resident in the East Kootenay, translocated there, or descended from translocated badgers, spans 1996 to 2006, and extends from Yoho National Park nearly to the Montana boundary. We have also accumulated >1000 badger sightings made by the public (Chapter 3) and there are now more map products to use as bases for assessing habitat use. Another consideration is that habitat modeling is based on selection ratios for each habitat class. Univariate assessments of badger habitat use indicate "avoidance" of a habitat class when the percentage of badger locations in it is less than the percentage of the landscape consisting of that class. Because of this, habitat modeling can show avoidance of heavily used habitat classes if those classes are sufficiently common on the landscape, so it is arguable whether this approach always reflects their true value. Related to this point, comparing use to availability typically results in models that are specific to local conditions at a given time, making it impossible to directly extrapolate them to other locales or into the future. One result of this situation has been that fine-scale planning for badgers within the East Kootenay is sometimes impeded by an inability to interpret the potential quality of habitat at a given site. In addition, provincial-level work of the *jeffersonii* Badger Recovery Team has been hampered to some extent by lack of knowledge regarding badger use of various habitat classes. Therefore, we chose to assess use of classes within a number of habitat variables, as indicated by both radiotelemetry data (Chapter 1) and sightings (Chapter 2, Chapter 3) to:

1. provide baseline habitat-use information relating to a wide variety of topographic, biophysical and vegetation mapping products, with potential utility both within and beyond the East Kootenay; and
2. determine whether sightings provide habitat-use information that is representative of that determined through radiotelemetry.

We consider this to be a preliminary analysis. Future decision-making requirements are likely to dictate the direction of more detailed analyses, which can be conducted using the databases created. We do not intend to identify critical habitats nor to prioritize classes of habitat variables in this chapter. Rather, our intent is simply to determine the range of habitat conditions used by badgers, to provide broad guidance for future habitat-planning exercises.

Methods

The number of telemetry records per badger (Chapter 1) was highly variable and in some cases, particularly when badgers were first radiotagged, the monitoring intensity was very high. To reduce any bias toward habitats used by individual badgers monitored for long periods and to reduce the autocorrelation between sequential locations, we (1) eliminated animals for which only 1 record was available (i.e. those that were captured but not radiotagged or died immediately after capture); (2) eliminated records representing the release location of translocated animals; (3) removed all but 1 record in cases where several animals occurred together, such as a mother and offspring traveling together or several siblings at a maternal den; (4) thinned the remaining telemetry dataset for each badger so that there was at least 4 days between locations; (5) determined the median number of records remaining per individual (26); and (6) randomly subsampled the remaining telemetry records to obtain no more than 26 records per individual.

Sightings made by the public have variable (and unknown) levels of accuracy and bias, and may or may not represent spatially or temporally independent observations. However, we had no method to reliably correct for these problems. In any event, one of our aims was to compare the sightings against what is presumed to be the more representative telemetry-data sample.

We forwarded telemetry and sightings records to the Columbia Basin Fish and Wildlife Compensation Program office in Nelson, British Columbia. Staff there used GIS methods to extract habitat attributes for each record (Table 4.1). In some cases, map polygons included several components, such as two or more tree species or up to three soil associations. When this occurred, we considered only the most common component. Coverages were incomplete for some variables, and in such cases we used the results but noted the sample sizes. Some habitat variables used are essentially immutable (such as elevation or biogeoclimatic zone). Others, such as forest cover, change over time, so the date of mapping in relation to the date of badger records will have some influence. In such cases, the mapping generally fell within the time of badger data collection (Table 4.1) and the rate of change in habitat variables is relatively slow, so the effect on results should be minimal.

Table 4-1. Sources for extraction of habitat attributes at badger telemetry and sightings locations. All digital databases provided by Columbia Basin Fish and Wildlife Compensation Program, Nelson, British Columbia.

Variable	Source/Scale	Current	Notes / Website With Standards
elevation	digital elevation model based on 50-m pixels	N/A	generated by Min. Sustainable Resource Mgmt, Nelson, BC
ecosection	1:20,000 Predictive Ecosystem Mapping	N/A	http://srmwww.gov.bc.ca/ecology/tem/list.html
biogeoclimatic zone	1:100,000 Provincial Digital Biogeoclimatic Subzone Variant map (abec_bc and abec_r4 [version 5])	N/A	http://www.for.gov.bc.ca/hre/becweb/standards-becdb.htm
parent material	1:50,000 soils and surficial geology mapping; NTS map sheets 82F, 82G, 82J, 82K	N/A	http://ilmbwww.gov.bc.ca/risc/pubs/earthsci/terrain/index.htm
surficial material texture	1:50,000 soils and surficial geology mapping; NTS map sheets 82G, 82J	N/A	http://ilmbwww.gov.bc.ca/risc/pubs/earthsci/terrain/index.htm
landform (surface form)	1:50,000 soils and surficial geology mapping; NTS map sheet 82K	N/A	http://www.em.gov.bc.ca/Mining/Geolsurv/Terrain&Soils/frbcguid.htm
surface expression	1:50,000 soils and surficial geology mapping; NTS map sheets 82G, 82J	N/A	http://ilmbwww.gov.bc.ca/risc/pubs/earthsci/terrain/index.htm - if surficial material conformed to underlying topopgraphy, material depth reported; otherwise surficial landform reported
present land use	1:250,000 Baseline Thematic Mapping	1997	http://ilmbwww.gov.bc.ca/bmgs/products/btmspecn.pdf
ecosystem unit	1:20,000 Predictive Ecosystem Mapping	N/A	http://srmwww.gov.bc.ca/ecology/tem/list.html - site series aggregated based on vegetation characteristics
forest cover	1:20,000 Forest Inventory Planning mapping	2000/01	http://srmwww.gov.bc.ca/tib/reports/datadictionary/rpt_fip_rddv2.pdf - non-productive codes, leading species, overstory age, crown closure, disturbance history and site index
distance to nearest road	1:20,000 Terrain Resource Information Mapping; distances calculated using 20-m pixels	1997	http://ilmbwww.gov.bc.ca/bmgs/trim/trim_specs.html
road density	as above; moving window of 33x33 30-m pixels	N/A	http://ilmbwww.gov.bc.ca/bmgs
land ownership	1:20,000 Forest Inventory Planning mapping	2000/01	http://www.for.gov.bc.ca/hts/inventory/reports/codes/index.html

Results

After thinning, our dataset included 1008 telemetry records from 53 badgers. The sightings dataset also had, coincidentally, 1008 records. The following observations are in most cases based on smaller samples than this because coverage was incomplete for GIS databases or because the analyses are intentionally based on only a subset of the records (such as leading tree species for forested stands only).

Over half of telemetry records occurred at under 900 m elevation (Figure 4-1), with a median of 892 m and a range of 757 to 2439 m. The elevation distribution for sightings was slightly broader (range of 533 to 2603 m), with the lower elevations due to the inclusion of data from the Creston area. Despite this, the median elevation for sightings (914 m) was slightly higher due to more sightings than radiolocations at 900-1200 m (Figure 4.1). The great majority of both sightings and telemetry records were in the East Kootenay Trench ecosection (Figure 4-2). However, sightings extended more into ecosections to the southeast and southwest. Over 98% of telemetry records were within drier, lower-elevation biogeoclimatic zones (Montane Spruce, Ponderosa Pine and especially Interior Douglas-fir; Figure 4.3). Sightings records followed a similar pattern but with a broader range of zones used, particularly the Montane Spruce and Interior Cedar-Hemlock (Figure 4-3).

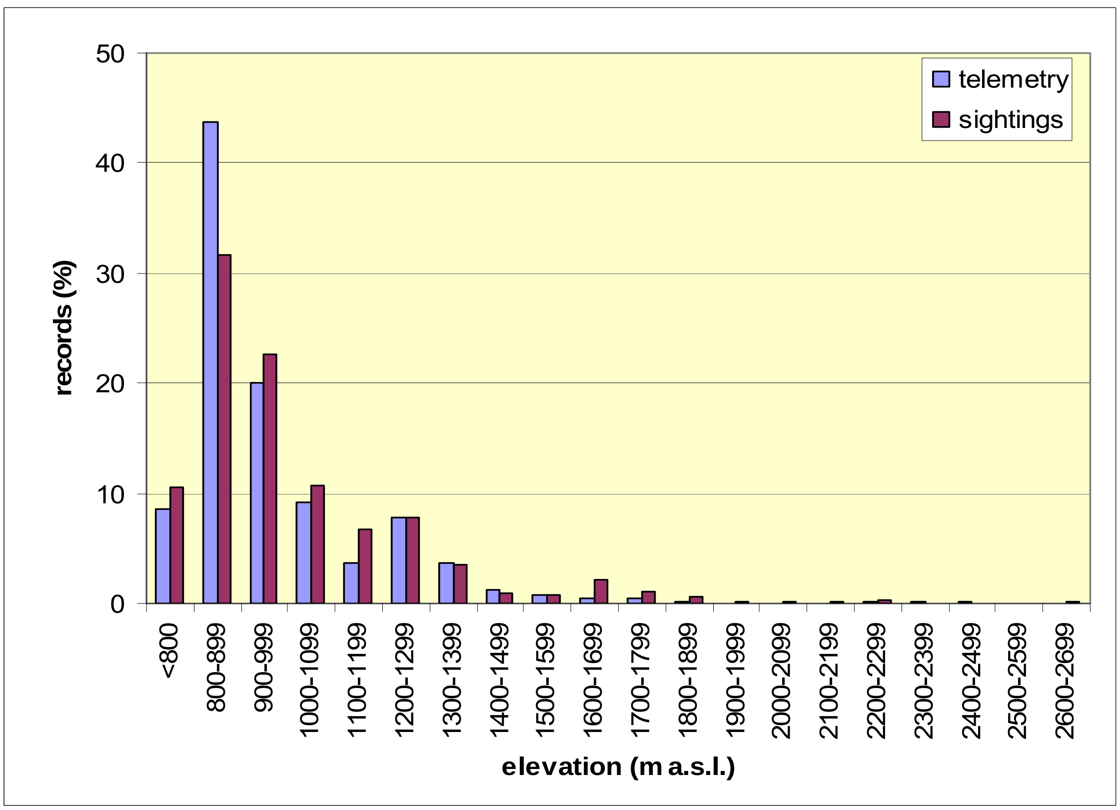

Figure 4-1. Elevation classes used by badgers radiotagged (n = 1006 from 53 badgers) versus sighted by the public (n = 1006) in the East Kootenay, 1996-2006.

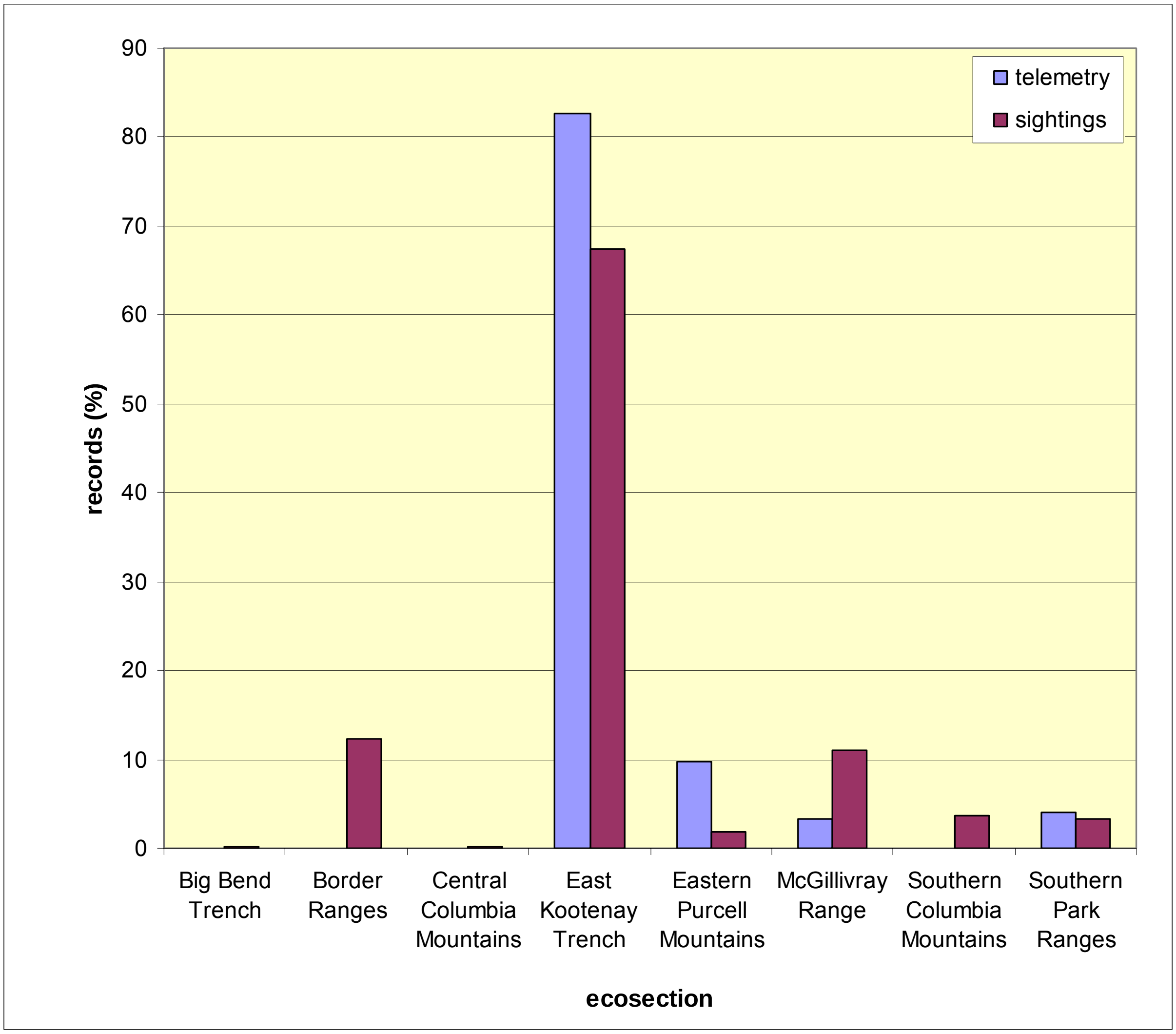

Figure 4-2. Ecosections used by badgers radiotagged (n = 1008 from 53 badgers) versus sighted by the public (n = 1008) in the East Kootenay, 1996-2006.

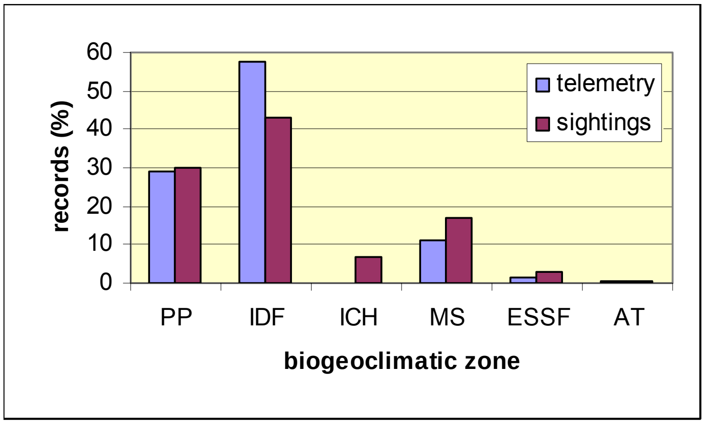

Figure 4-3. Biogeoclimatic zones used by badgers radiotagged (n = 1008 from 53 badgers) versus sighted by the public (n = 1008) in the East Kootenay, 1996-2006.

A variety of parent materials underlaid the sites used, but few locations were on bedrock, colluvium, organic material or undifferentiated materials (Figure 4-4). Telemetry and sightings records showed similar distributions, though with sightings having notably more glaciofluvial and fewer morainal sites. Surface texture coding was available for about half to two-thirds of records (most southern ones, no northern ones), and these locations only roughly approximated the total dataset with respect to parent material, so interpretation of texture classes must done cautiously. However, both datasets showed the use of a variety of texture classes, ranging mainly from silt to gravel with a concentration toward moderate textures (Figure 4-5). Similarly, landform classification was available for <10% of records, all from the north, and the thickness and expression of surface materials was noted for well under 50% of locations, all from the south. Within these, terraces, kame deposits, drumlinized terrain, fans and steepland were all commonly used (Figure 4-6) and surficial deposits occurred as both veneers and blankets (Figure 4-7), with similar patterns for sightings and telemetry records. Results for surface expression (Figure 4.8) were somewhat more variable between the 2 datasets. Both included undulating, rolling and hummocky land, fans, terraces and plains, but the sighting records included considerably more of the subdued forms (plains, terraces, undulating terrain) and less rolling land or steep slopes (Figure 4-8).

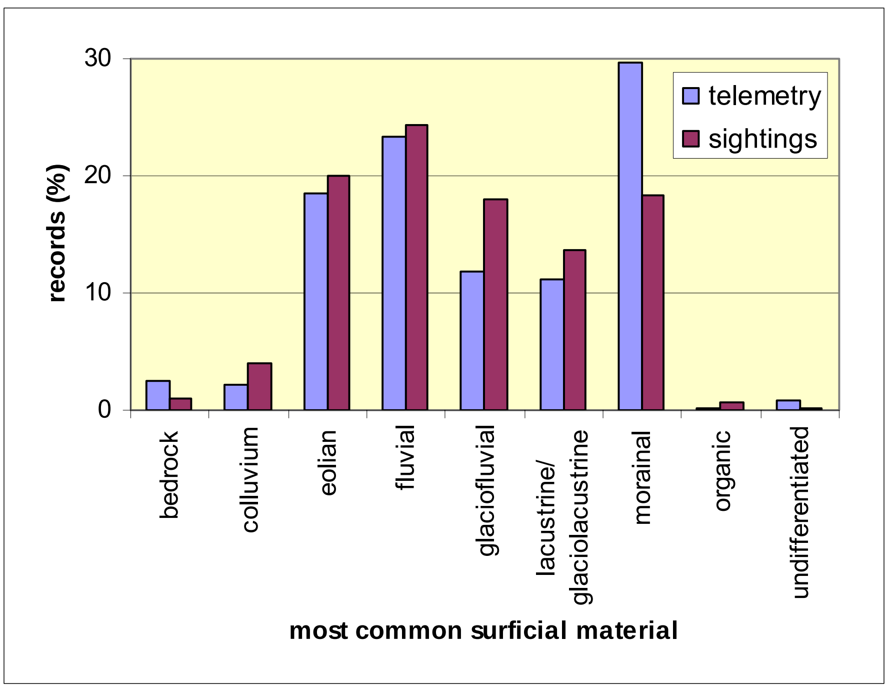

Figure 4-4. Surficial parent material used by badgers radiotagged (n = 1007 from 53 badgers) versus sighted by the public (n = 993) in the East Kootenay, 1996-2006.

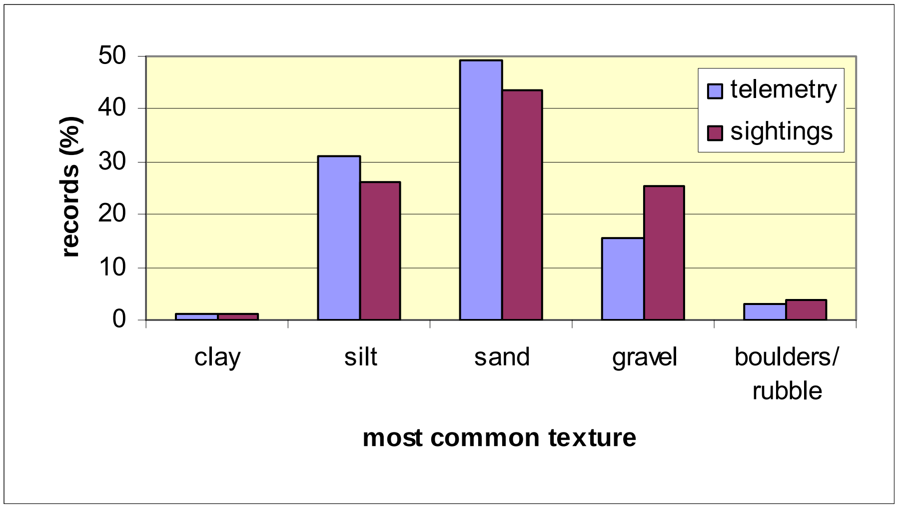

Figure 4-5. Surficial material textures used by badgers radiotagged (n = 545 from 37 badgers) versus sighted by the public (n = 689) in the East Kootenay, 1996-2006. Data incomplete; includes data only for portions of 82G and 82J NTS map sheets and no data for other map sheets.

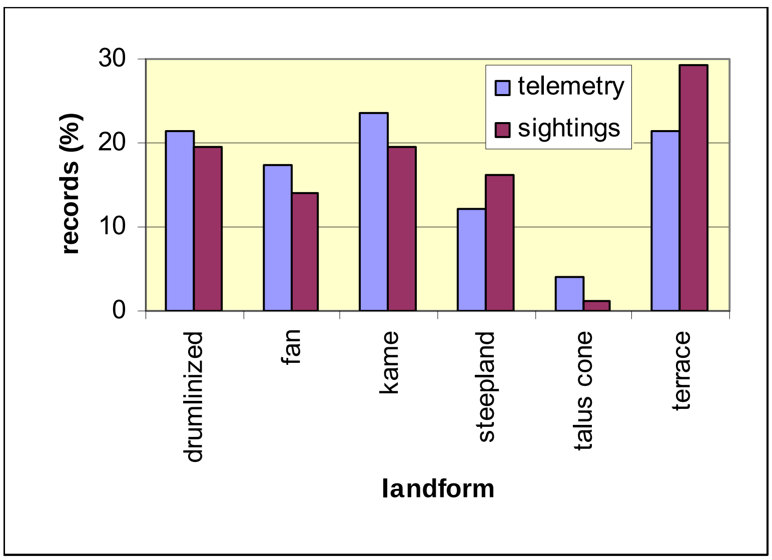

Figure 4-6. Landforms used by badgers radiotagged (n = 98 from 15 badgers) versus sighted by the public (n = 92) in the East Kootenay, 1996-2006. Data incomplete; includes data only for portions of 82K map sheet and no data for other map sheets.

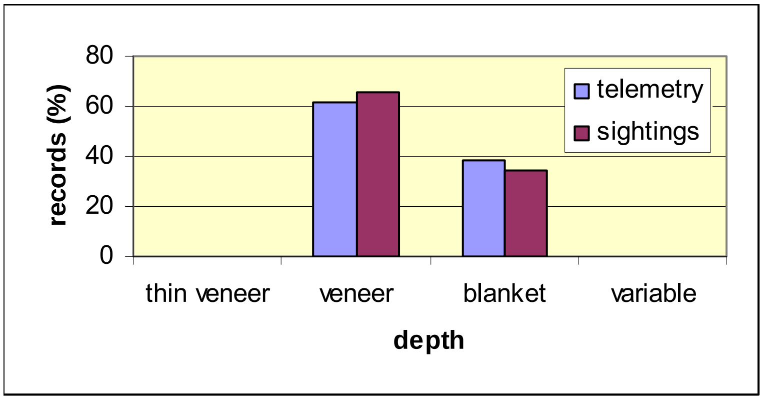

Figure 4-7. Predominant depth of surficial material over bedrock or underlying glacial at sites used by badgers radiotagged (n = 452 from 47 badgers) versus sighted by the public (n = 420) in the East Kootenay, 1996-2006. Data incomplete; includes data only for portions of 82G and 82J NTS map sheets and no data for other map sheets. Thin veneer = 2 – 20 cm, veneer = 10 cm to 1 m, blanket = > 1 m.

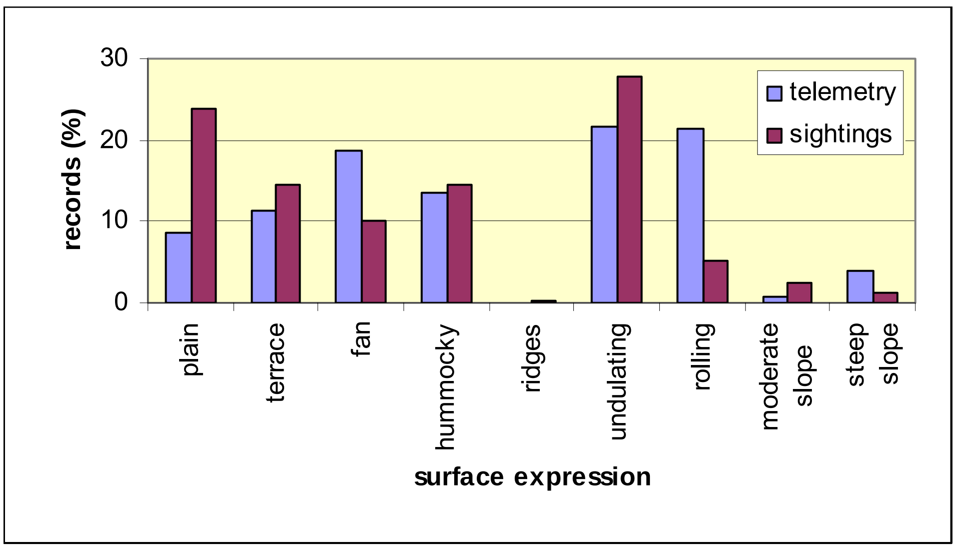

Figure 4-8. Surface expression at sites used by badgers radiotagged (n = 352 from 47 badgers) versus sighted by the public (n = 390) in the East Kootenay, 1996-2006. Data incomplete; includes data only for portions of 82G and 82J NTS map sheets and no data for other map sheets.

Given the great number of land-use classes and the coarse scale of land-use mapping (1:250,000), differences between the 2 datasets were to be expected. Those with the greatest proportional difference included more sightings than telemetry locations in mining, urban, residential/agricultural mix, recreational land and water classes (all of which are land uses with a high human presence), and fewer sightings in burns (Figure 4-9). Other classes differed proportionately little between datasets. Regardless of the dataset, most records occurred in land classified as agriculture, young forest, logged, rangeland, selectively logged and urban (Figure 4-9).

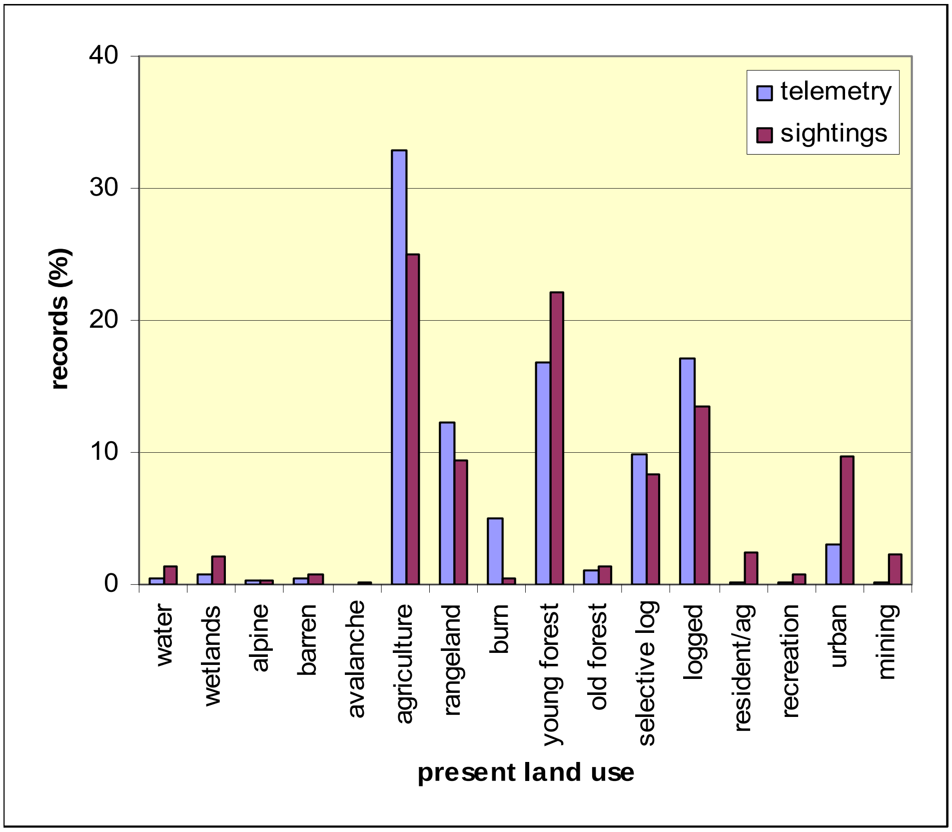

Figure 4-9. Land-use classes used by badgers radiotagged (n = 1008 from 53 badgers) versus sighted by the public (n = 1006) in the East Kootenay, 1996-2006.

For both the telemetry and sightings databases, the 4 most-used ecosystem units had climax conditions characterized by grassland, forests having a pinegrass understory, forested grassland, and forests with a soopolallie understory (Figure 4-10). However, sightings records were somewhat more evenly distributed among classes, and about 1 in every 7 was in an area mapped as urban/suburban.

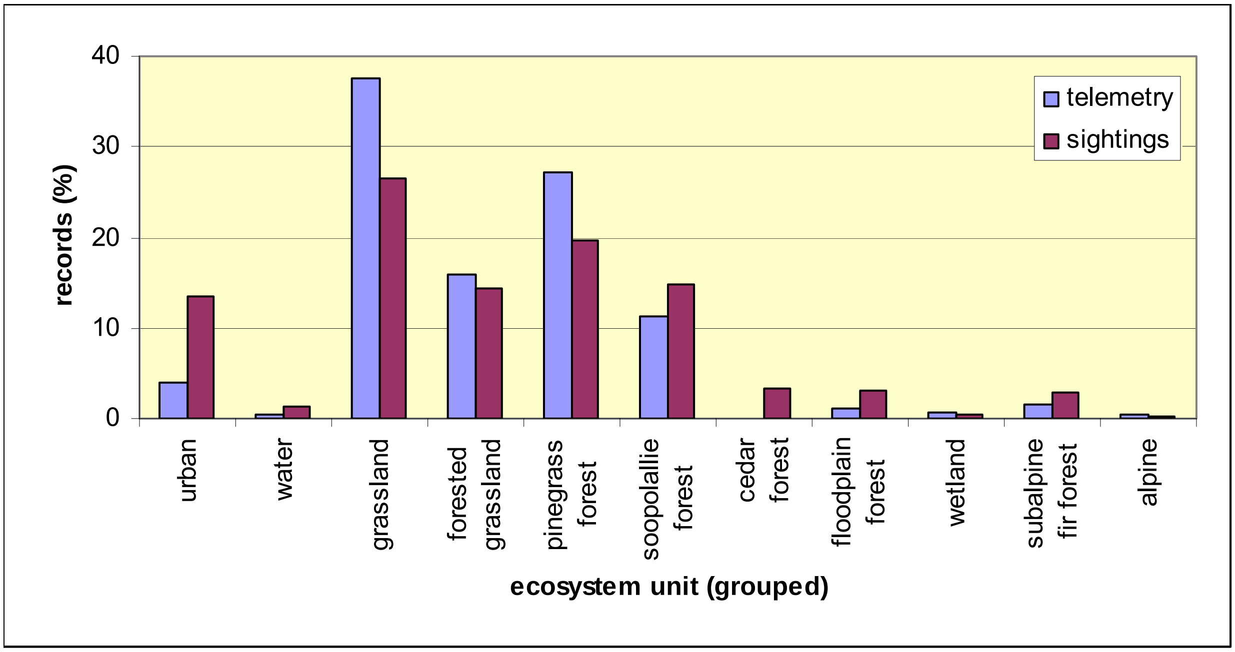

Figure 4-10. Ecosystem units used by badgers radiotagged (n = 1008 from 53 badgers) versus sighted by the public (n = 999) in the East Kootenay, 1996-2006. Units reflect expected climax conditions and are based on groupings of units identified through Predictive Ecosystem Mapping. “Water” includes gravel bars, rivers, lakes and ponds; “pinegrass forest” includes all units with pinegrass, prince’s pine or parsley fern as an identifying feature; “soopolallie forest” includes all units with soopolallie as an identifying feature, and the PPdh2AR unit.

Based on forest-cover mapping, over half of badger locations were on sites that were non-productive for forestry, regardless of which dataset was examined (Figure 4-11). Of the non-productive types, about 85% of telemetry points were in clearings (typically agricultural) and open range, while for the sightings dataset over 90% were fairly evenly split between clearings, urban and open range (Figure 4-12). The “non-productive - urban” designation accounted for nearly one-third of sightings, but in forest-cover mapping this includes roadways and disturbed areas adjacent to them. Douglas-fir was the predominant tree at forested sites for both tagged badgers and sightings, but while it was by far the most common among telemetry records, it was nearly matched by lodgepole pine among sightings (Figure 4-13). All other trees commonly occurring at low to moderate elevations within the East Kootenay were used to some extent, except western redcedar. Excluding permanently non-forested sites, badgers occurred commonly in stands 20 years or younger, were less common in slightly older stands, were frequently recorded again in maturing stands, and were seldom found in older stands (Figure 4-14), regardless of dataset. However, such differences among age classes were less pronounced within the sightings records. A parallel situation occurred for crown closure, with peaks at the lowest and moderate closure, and both smaller differences among classes and a greater median value for the sightings database (Figure 4-15). Of forested stands for which the disturbance history was noted, most had either been burned or logged (Figure 4-16), though with sightings being more commonly in logged than burned areas and with a greater variety of previous activities. Site indices of forested stands covered a wide range. About 90% were between 10 and 20 (Figure 4-17) with a median index of 15.2 for sightings, compared to 13.5 for telemetry locations.

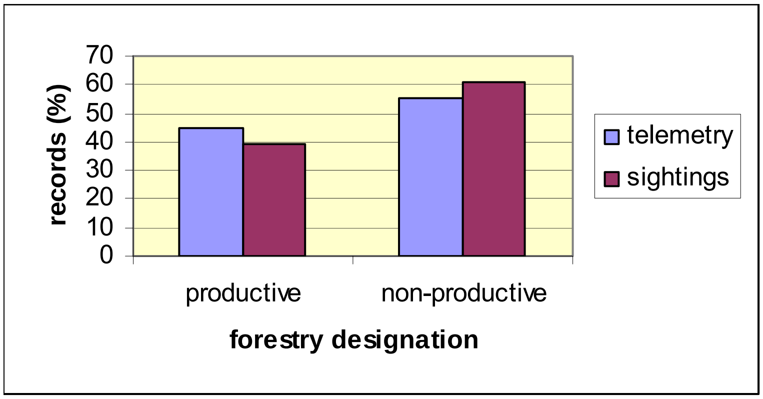

Figure 4-11. Forestry designation at sites used by badgers radiotagged (n = 979 from 53 badgers) versus sighted by the public (n = 960) in the East Kootenay, 1996-2006.

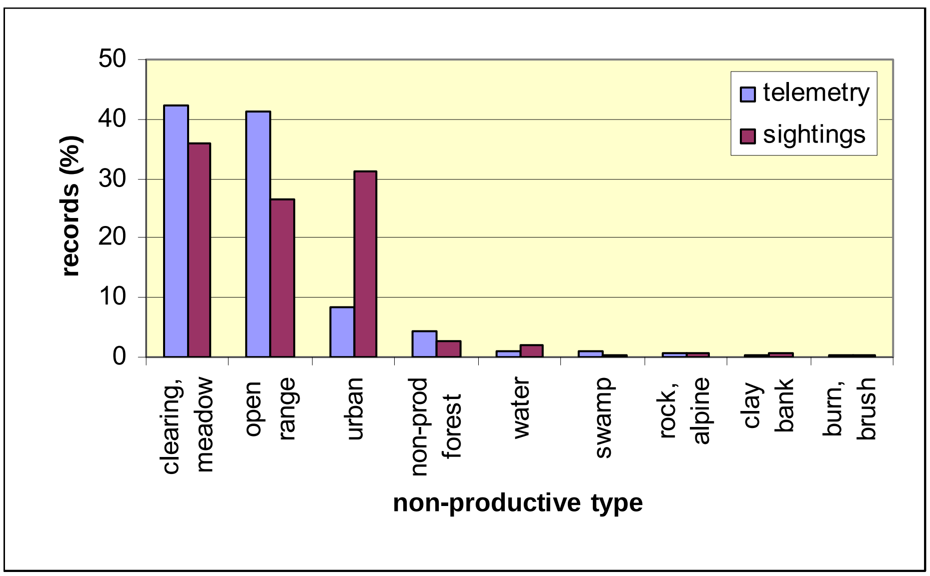

Figure 4-12. Non-productive cover classes used by badgers radiotagged (n = 541 from 50 badgers) versus sighted by the public (n = 584) in the East Kootenay, 1996-2006.

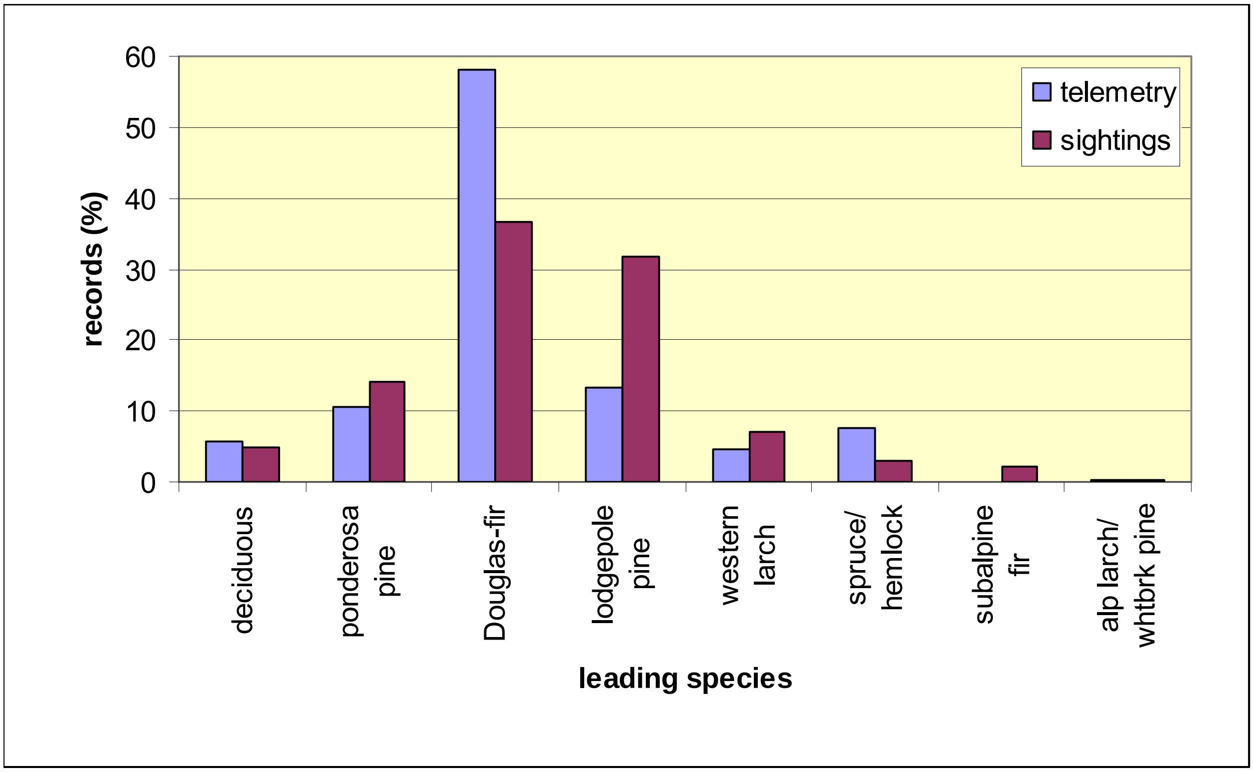

Figure 4-13. Leading tree species in forested stands used by badgers radiotagged (n = 391 from 49 badgers) versus sighted by the public (n = 360) in the East Kootenay, 1996-2006.

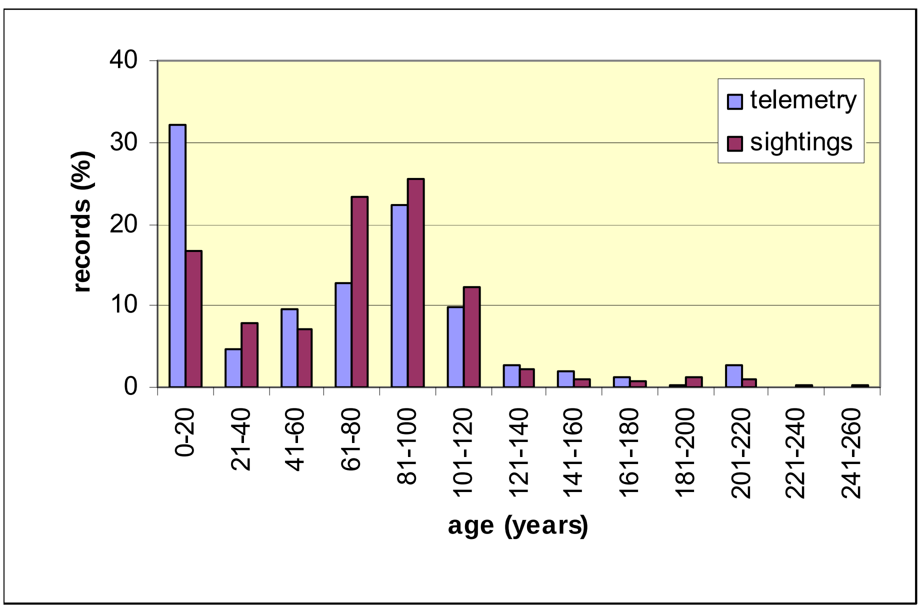

Figure 4-14. Overstory age in forested stands used by badgers radiotagged (n = 462 from 49 badgers) versus sighted by the public (n = 389) in the East Kootenay, 1996-2006.

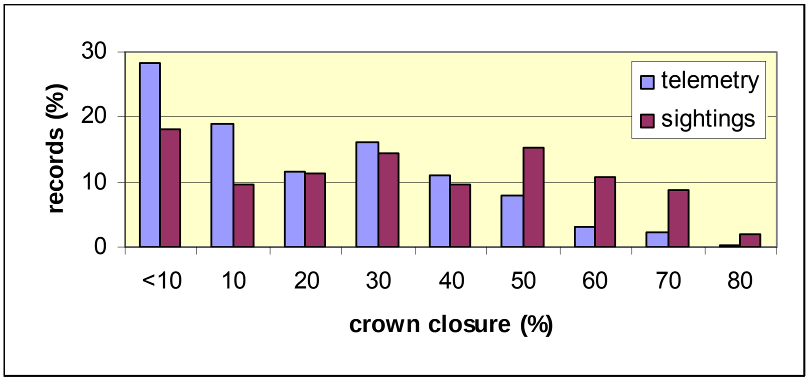

Figure 4-15. Overstory crown closure in forested stands used by badgers radiotagged (n = 462 from 49 badgers) versus sighted by the public (n = 390) in the East Kootenay, 1996-2006.

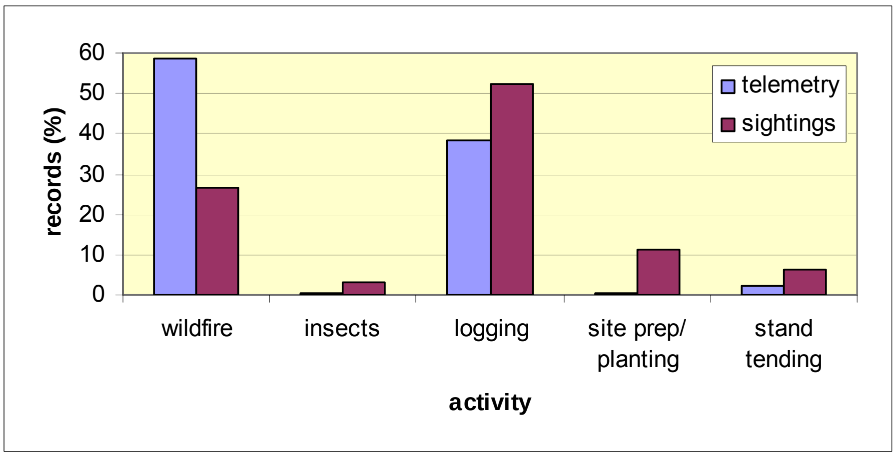

Figure 4-16. Stand history, where noted, in forested stands used by badgers radiotagged (n = 371 from 43 badgers) versus sighted by the public (n = 210) in the East Kootenay, 1996-2006.

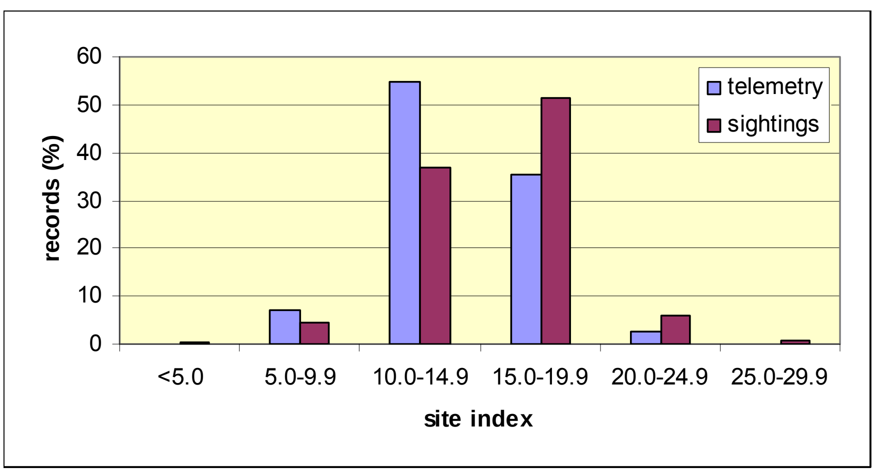

Figure 4-17. Site index (predicted height [m] of trees when 50 years old) in forested stands used by badgers radiotagged (n = 463 from 49 badgers) versus sighted by the public (n = 390) in the East Kootenay, 1996-2006.

Most badger radiolocations were within 200 m of mapped road, especially among sightings (Figure 4-18). Even within the first 200 m, badgers tended to be preferentially near to the road, particularly among sightings (Figure 4-19). Correspondingly, most locations were in areas having over 2.5 km of road per km^2, and with little difference between telemetry locations and sightings records (Figure 4-20). For both telemetry locations and sightings, over half were on private land and most of the rest on provincial Crown land (Figure 4-21). About 7% of telemetry locations fell within Indian reserves, while about 2% of sightings fell in each of parks and Indian reserves.

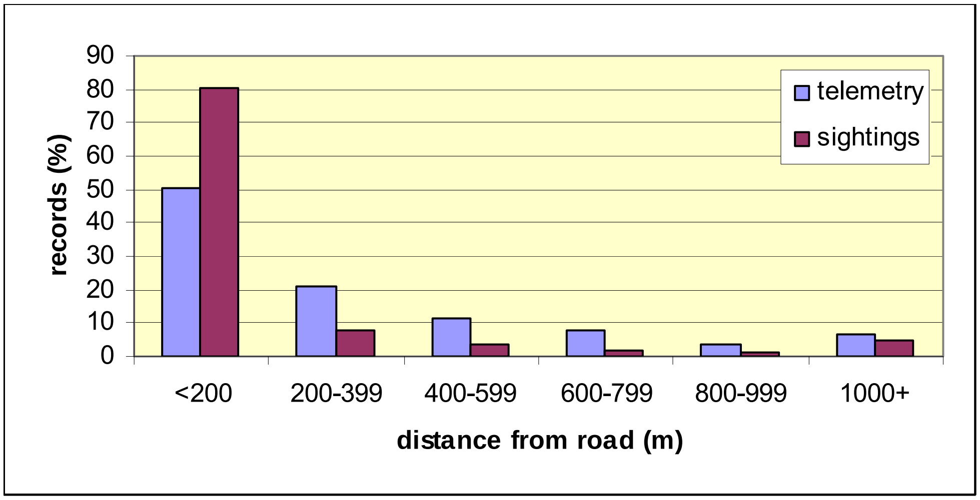

Figure 4-18. Distance from nearest road of sites used by badgers radiotagged (n = 1007 from 53 badgers) versus sighted by the public (n = 1008) in the East Kootenay, 1996-2006.

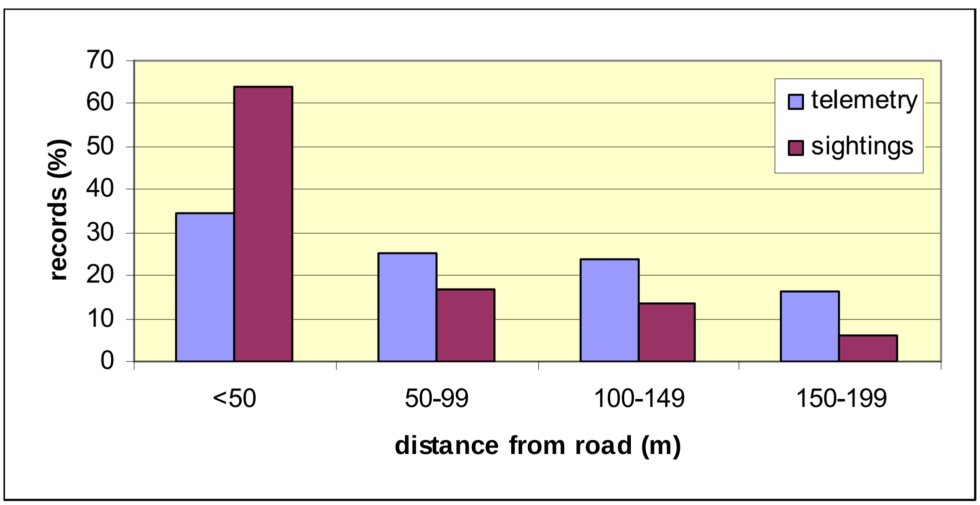

Figure 4-19. For locations within 200 m of nearest road, distance from nearest road of sites used by badgers radiotagged (n = 505 from 51 badgers) versus sighted by the public (n = 810) in the East Kootenay, 1996-2006. Data is a subset of that presented in Figure 4-18.

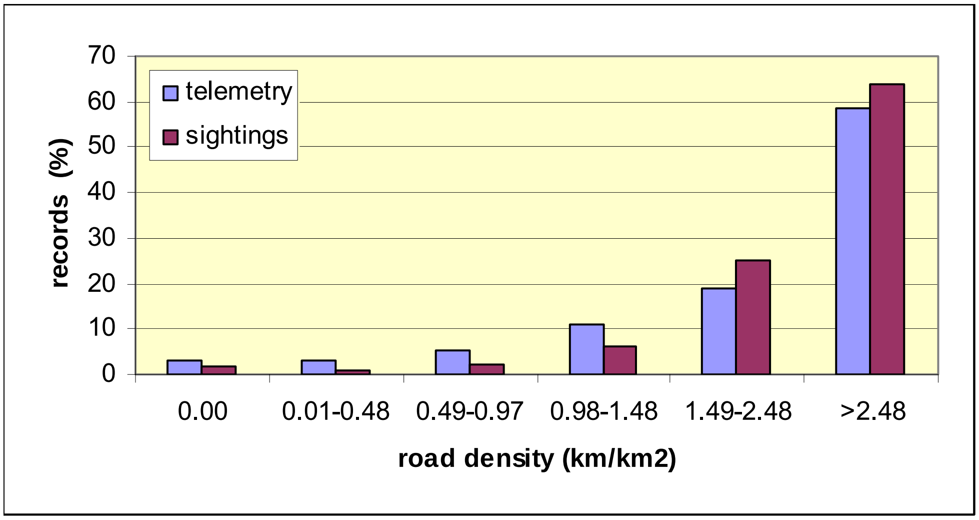

Figure 4-20. Density of roads around sites used by badgers radiotagged (n = 1008 from 53 badgers) versus sighted by the public (n = 1008) in the East Kootenay, 1996-2006.

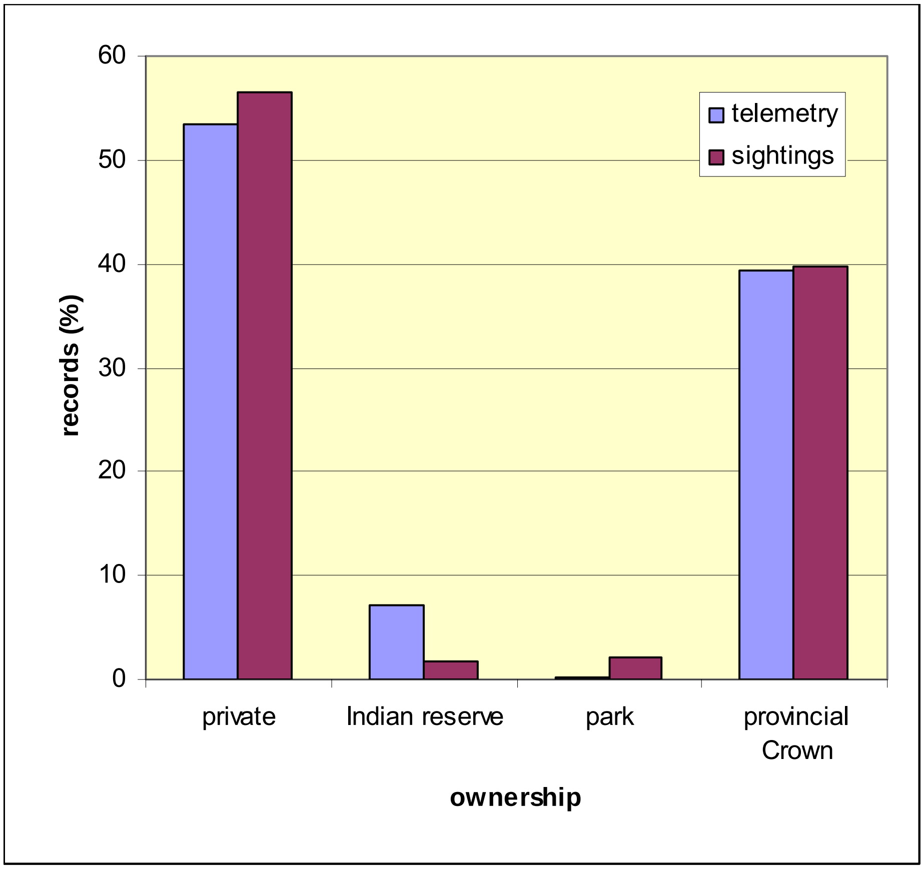

Figure 4-21. Land ownership for sites used by badgers radiotagged (n = 1008 from 53 badgers) versus sighted by the public (n = 1008) in the East Kootenay, 1996-2006. Parks are national, provincial and regional.

Discussion

Considering both the radiotelemetry and sightings data, it is clear that badgers occurred widely across the East Kootenay and used almost the full range of habitats available with respect to ecosystems, vegetation, physiography and soils. However, some trends were clear. There was an apparent concentration of activity at low elevations, particularly within the IDF, PP and to a lesser extent the MS in the East Kootenay Trench. Surficial materials that are excessively coarse or fine were used little. Pasture and rangeland supported the majority of activity, but recently logged areas and young forest were also heavily used, particularly in locations where climax stands were of drier forest types dominated especially by Douglas-fir. Somewhat surprisingly, given our understanding of badgers as being associated with open areas, there was considerable use of relatively mature forest stands (e.g. 60-120 years), including those with relatively high crown closures and site indices, and of several ecosections dominated by forest. Badgers also commonly occurred along roadsides and in other developed areas, with about 1 in 6 radiolocations falling within 50 m of a road and most falling on private land.

Despite the similarities between the 2 datasets, some differences between locations recorded through telemetry and those reported as sightings were evident. This is not surprising, given that human observers are not uniformly distributed across the landscape. Thus, considerably more sightings than telemetry records occurred adjacent to highways, in locations designated under various habitat classifications as urban, in parks and in other places with a greater human presence. Other differences likely related to the fact that sightings and telemetry records did not come from exactly the same land base. While both were concentrated in the Trench, many sightings came from the Elk Valley, the McGillivray Range and the Creston area (Chapter 3), whereas none of the radiotagged badgers used those areas. Thus the sightings sample showed, for example, greater use of the ICH zone, mines, and older, more closed forests dominated by trees typical of higher elevations. This alone could account for the general trend toward more uniform use of more habitat classes per habitat variable among the sightings sample. However, it is likely that the lower location precision for sightings was partly responsible, causing an increase in erroneous locations and therefore greater apparent use of some little-used habitat classes. Despite screening the telemetry database to reduce the effect that individual badgers would have on results, some of the difference between the 2 datasets was also likely due to chance effects relating to where badgers were targeted for capture and radiotagging, or the portion of the region through which roads pass. Much of the radiotagged badger dataset came from animals whose home ranges included major burns (especially those on Fir Mountain and the Lussier River, but also including older burns in the Trench), resulting in a disproportionately high representation of burned land for the present land use and stand history variables for the telemetry data relative to sightings. Surficial parent materials also vary considerably within and between ecosections so differential use of some parent materials between the 2 datasets may be reflective of availability as much as selection.

The significance of differences between sightings and telemetry datasets can be interpreted in several ways. It can be assumed that the sightings database was biased to areas near roads and habitation and records within it were generally not as accurate as those in the telemetry database, so it was not entirely representative of regional badger habitat use as a whole. This is undoubtedly true to some extent, particularly for variables measured at a finer scale and that are highly correlated with roads, such as distance to roads or amount of urban land. However, the sightings database also gave a broader geographic and ecological view, including coverage for areas that have low badger densities or are remote from core research areas and are therefore not practical for conducting capture work. These areas represent large amounts of land and therefore may support significant portions of the regional badger population, despite the potential low density. In essence, sightings can expand a study area into locations that would otherwise be uneconomical to survey. For example, we would have little information about habitat use by badgers at mid elevations outside of the Trench if it were not for the numerous sightings reported from the Elk Valley and McGillivray Range.

In the future, one approach to using the consistent, accurate and (at the fine scale) unbiased data generated by telemetry while still taking advantage of the broader coverage and apparently minimal broader-scale bias provided by sightings would be to stratify analyses. For example, the telemetry data likely offered a representative sample of badger activity within the East Kootenay Trench and Eastern Purcell Mountains ecosections. However, it provided no sample for the Southern Columbia Mountains, Border Ranges and most of the McGillivray Range, areas for which nearly 300 sightings were available. This pattern likely holds true for other areas of British Columbia where both sightings and telemetry or survey data exists. To address this issue, sightings could be compared to telemetry data only within ecosections or biogeoclimatic zones from which telemetry data had been obtained, to minimize the confounding effects of differing landscapes. This approach would more clearly demonstrate whether the two data sources provided different results and if so whether the differences could be minimized by considering characteristics within larger landscapes or “buffers” surrounding each record, rather than individual pixels. If differences were minimal (either at the pixel scale or within the buffer), the sightings dataset could be combined with the telemetry data within those ecosections or zones. A lack of difference within that stratum would also suggest that sightings were representative of badger activity in general and sightings could therefore be used as the sole basis for habitat assessments in ecosections or zones where telemetry data was not available.

Several limitations to the use of GIS data were apparent in this exercise, and should be considered for future analyses.

1. Mapping of micro-habitat features does not exist. If habitat use reflected fine-grained decisions regarding site features that were not correlated to coarser scale features for which mapping did exist, it would not be possible to assess the use of those features through GIS approaches.
2. For some map layers, individual polygons included several classes, such as up to 6 tree species or up to 3 soil associations. Our assessment was based solely on the most common class per polygon. Assessing multiple states for per badger record would greatly increase the complexity of analysis, but it must be recognized that considering only the leading class results in some loss of resolution.
3. Some variables were not consistently available or consistently coded across the project area. This was largely due to differing ages of source data among map sheets or different interpretations by mappers, but did occur within mapping projects. It was particularly true for terrain mapping (such as the surface expression or landform variables), and would likely be true in any large study area.
4. A related issue is that some mapped habitat variables are essentially unusable. For example, PEM mapping includes a field for site modifiers to describe atypical conditions, but we were unable to rely on this data as only 3 codes (of 20) were applied among the >2000 records, with 90% of locations for both datasets given a code indicating gentle slopes; this is unlikely to have so uniformly represented an atypical condition. Similarly, surface expression coding involves 2 concepts. If surficial material conforms to the shape of underlying bedrock or a deeper layer of material, then the expression (e.g. drumlinized) is not listed; instead the depth of surface material thickness is given. Therefore, it is not possible to get complete and unbiased information on either the landform or the depth of surface materials, both of which could otherwise be of value in describing badger habitat.
5. There is some overlap among GIS mapping bases in the use of concepts or terms. For example "urban" is a much more inclusive term in 1:20,000 forest cover mapping than in 1:20,000 PEM mapping or 1:250,000 mapping of present land use. Understanding the ways that terms are used is key to interpreting habitat use assessments.
6. Caution must be used when interpreting results of habitat variables that describe potential or climax conditions. Most badger activity was in PEM units whose climax state is forest or grassland, but most of these sites had been either recently or permanently disturbed. Without adding the complexity of assessing structural stage within each PEM unit, interpretation of this mapping is limited to assessing the "types of places" that badgers occur rather than the precise current conditions.
7. The use of any mapping based on current conditions (such as forest cover or roads) will result in some badger records being chronologically mismatched with the mapping. For example, a forest that had not been harvested at the time of mapping might later be logged and then used by a badger; if so, the dataset would show the badger to be in a forest instead of a recent cutblock.
8. Geographic error is present in any animal location database, especially for sightings reported by the public. The degree of error is likely greater when estimating UTM coordinates then later projecting them on GIS bases than when measuring attributes in the field at the time of telemetry data collection. Error will tend to make habitat use patterns less distinct. In particular, habitat classes that

are small or dendritic but disproportionately used by badgers will tend to be misclassified. For example, if badgers used recent cutblocks that are relatively small and in a landscape dominated by unharvested or regenerating forest, then even relatively small errors in location would tend to indicate that badgers were located in older forests with greater crown closure. It is not hard to imagine other landscape configurations in which an average error of a few hundred metres would tend to result in most records being misclassified. While this is not likely the norm, it probably occurs in some areas or habitat variables. Thus, results that appear to be strongly at odds with our understanding of badger ecology, especially if those results are obtained via sightings, should be examined carefully.

Acknowledgements

In addition to those who helped fund, administer and conduct fieldwork for the East Kootenay Badger Project (Chapter 1), we thank M. Schnider and A. Waterhouse of the Columbia Basin Fish and Wildlife Compensation Program for extracting habitat attributes for badger radiotelemetry and sightings locations, and M. Ketcheson and C. Jones for assistance in interpreting PEM mapping codes. We are also grateful to the nearly 1000 people who reported sightings to us.

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