Effectiveness Evaluations for the Fir Mountain, Johnson Lake and Ta Ta Creek Airport South Badger Wildlife Habitat Areas in 2006

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Fir Mountain WHA

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Summary

Based on a recently developed protocol, we conducted effectiveness evaluations in 2006 for 3 Wildlife Habitat Areas (WHAs) established for badgers in the East Kootenay area of British Columbia. Ratings were developed relating to the functionality of these WHAs and the level of risk they face. Functionality was based on the density of recent ground squirrel and badger burrows, and whether there had been evidence of females, family groups or maternal dens in the WHAs within the previous 6 years. Risk factors related to the state of and trends in habitat quality, and the degree of roadkill mortality risk.

We rated all 3 WHAs as highly functional, but we considered 2 of the 3 to have long-term mortality risk factors. Thus, the Fir Mountain WHA received an effectiveness rating of 5 out 5, whereas the Johnson Lake and Ta Ta Creek Airport South WHAs were rated at 4 out of 5.

As part of this assessment, we proposed thresholds between "low" and "high" burrow densities for both badgers and Columbian ground squirrels, for use in assessing the functionality of WHAs.

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Acknowledgements

We thank Corinna Hoodicoff and Brian de Jong, Summit Environmental Consultants Ltd., Vernon, for conducting all GIS analyses required to determine road densities, area of permanent habitat loss and canopy closure classes. This assessment was funded by the Ministry of Forests and Range. Wayne Erickson administered the contract and reviewed an earlier draft.

1. Introduction

The subspecies of American badger occurring in British Columbia (*Taxidea taxus jeffersonii*) is listed as nationally endangered and is on the provincial "red" list. Wildlife Habitat Areas (WHAs) have been established in the East Kootenay area for the purpose of conserving badgers, and have been proposed elsewhere. A protocol for monitoring the effectiveness of these WHAs has recently been completed (Newhouse et al. 2007). We used that protocol as a guide to assess 3 recently established WHAs in the East Kootenay.

The sampling protocol definition of effectiveness includes both functionality and risk. Functionality factors include (a) whether a female or family group has occurred in the WHA in the past 6 years; (b) the density of recent badger burrows (and where possible, the trend over time), and (c) where appropriate, such as the East Kootenay, the density of recent ground squirrel burrows (Figure 1). These functionality ratings are to then be modified based on subjective judgments of whether there are immediate risk factors (likely to impair use of WHA within 5 years), long-term risk factors (likely to arise within 5 to 10 years), or low to no risk factors. Risk factors include degree of land alienation, trends in canopy closure, roadkill risk as a function of road density, traffic volume, adjacency of badger activity to a highway and number of roadkills, a rapid on-site assessment, and grassland status within the WHA. The protocol then calls for combining functionality and risk to rate the effectiveness of a WHA (Table 1).

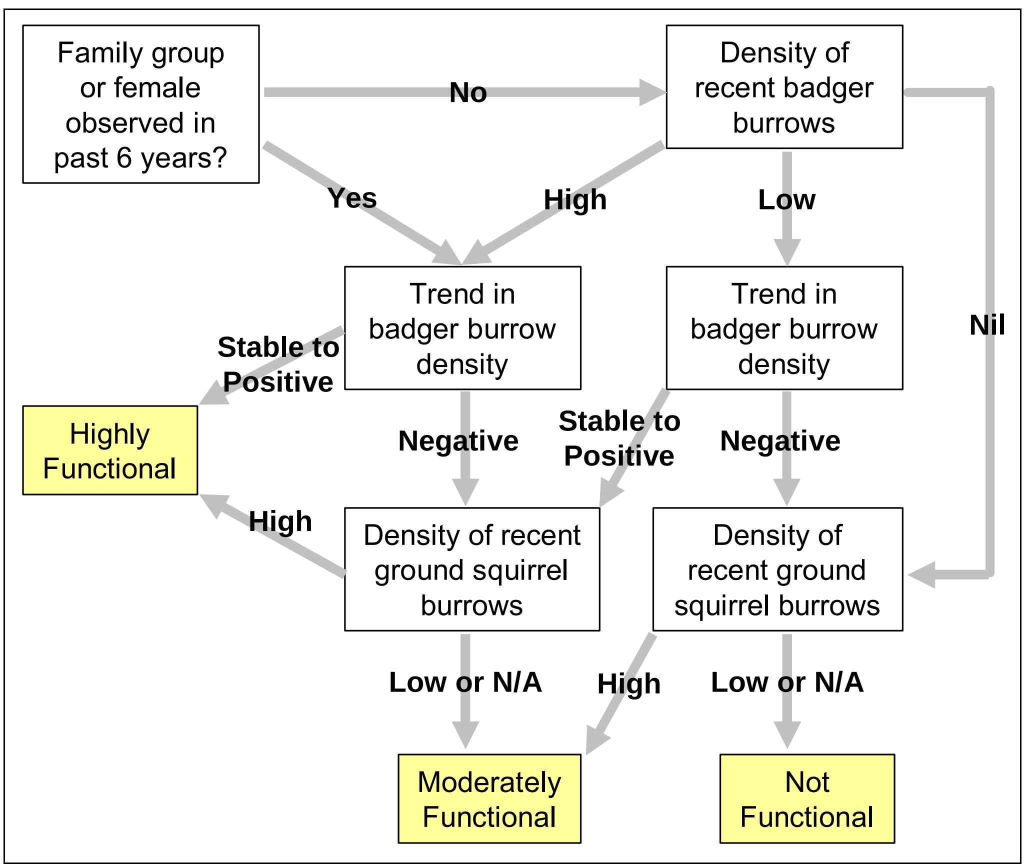

Figure 1. Assessment process for assigning badger WHA functionality ratings, from Newhouse et al. (2007).

Table 1. Badger WHA effectiveness categories, from Newhouse et al. (2007). Higher numbers correspond to greater effectiveness.

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

Two limitations to conducting the assessments were that the monitoring protocol is based in part on (a) temporal trends in the burrow densities of badger burrows and their main prey in the East Kootenay, Columbian ground squirrels (*Spermophilus columbianus*), and (b) whether there are high densities of recent badger or ground squirrel burrows. Temporal trends cannot be determined from field sampling within a single year, and the threshold between "low" and "high" density is to be determined from baseline monitoring which has not yet been done. Because of this, the following document is intended to (a) establish burrow density values for 2006, to which future data can be compared; (b) tentatively establish the threshold above which badger and ground squirrel burrows will be considered to be at "high density"; and (c) provide preliminary ratings for each of the 3 WHAs monitored.

2. Methods

We conducted assessments at the Fir Mountain, Johnson Lake and Ta Ta Creek Airport South (TTCAS) WHAs (Figure 2). Field and office methods were as described in Newhouse et al. (2007). There were 140 transect segments at Fir Mountain, 33 at Johnson Lake and 515 at TTCAS. Field work was conducted mainly on 13 June 2006 at Fir Mountain, 17 July 2006 at Johnson Lake, and 11-17 July 2006 (1/4 of plots) and 28 August to 11 September 2006 (3/4 of plots) at TTCAS. GIS databases, including roads, VRI or forest cover and historic grasslands were assembled from the most current information available on government websites as of 29 November 2006.

The monitoring protocol recommends adjusting the observed density of ground squirrel and badger burrow observations based on date. The total number of burrows should be affected relatively little by date because they appear to persist for many years. However, the number of recent burrows (occupied during the year of survey) should normally be strongly affected by the sampling date. We therefore adopted the correction factors recommended in the protocol to account for variability in survey dates among WHAs or years (Appendix 1).

We defined preliminary threshold between "high" and "low" densities of ground squirrels and badgers. Data collected in 2006 from the 3 WHAs was compared to results from 201 random plots established in 1998, each comprised of 4 50-m x 2-m transects (400 m^2 or 0.04 ha) in the Interior Douglas-fir biogeoclimatic zone of the East Kootenay (N. Newhouse, Sylvan Consulting Ltd., unpubl. data; sampling methods described in Newhouse 1999), and to data from identical plots originating from 397 burrows where radiotagged badgers were located from June 1996 to July 2000 (N. Newhouse, Sylvan Consulting Ltd., unpubl. data.).

Based on past experience in the East Kootenay and specifically with the 3 WHAs investigated, we assume that ground squirrel burrows are those of Columbian ground squirrels. The only other possibility is the golden-mantled ground squirrel (*S. lateralis*), which is more commonly found in rocky areas, higher elevations and disturbed areas (Nagorsen 2005). It is possible that some of the burrows at the Fir Mountain site were made by golden-mantled ground squirrels. However, there is no reason to expect that this species would be less valuable as a prey species so any violation of our assumption should be of little consequence to the WHA assessments.

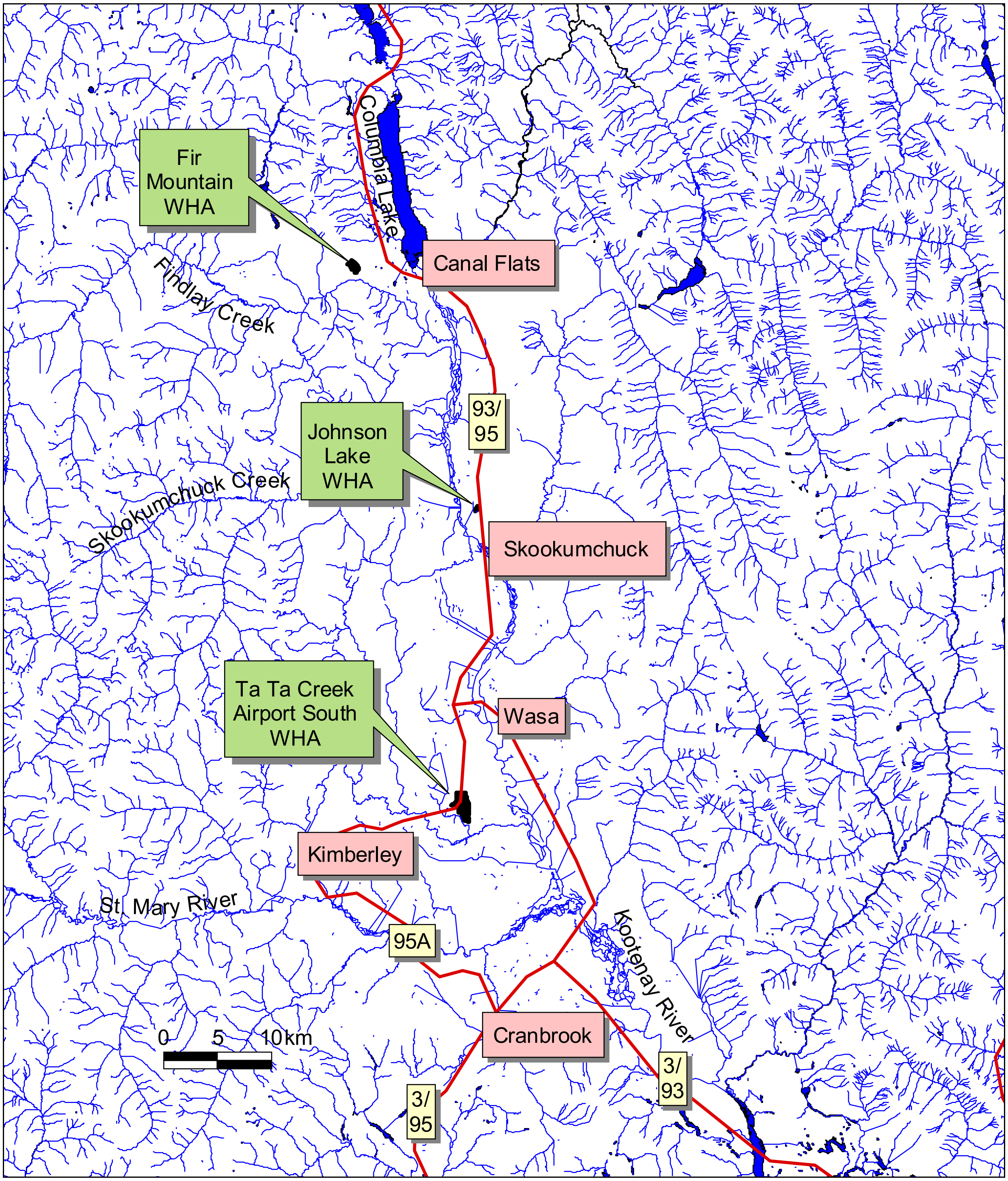

Figure 2. Locations of the 3 badger WHAs assessed in the East Kootenay during 2006.

3. Assessments Related to Functionality

3.1 Presence of Females, Family Groups or Maternal Dens

We searched for records of females or family groups within WHAs using sightings reported by the public to the East Kootenay Badger Project, Badger Hotline or the *jeffersonii* Badger Recovery Team website and investigated each badger burrow observed during field work, as required under the "Extensive" sampling protocols. We also searched a radiotelemetry database (N. Newhouse, Sylvan Consulting Ltd., unpubl. data), in accordance with the monitoring protocol's "Intensive" indicators. All database searches were limited to 6 years prior to the reference date of 6 October 2006.

For Fir Mountain, records included 2 known uses of the WHA by a radiotagged female on 15 July 2005 at UTM coordinates 577251 easting by 5556801 northing, and on 3 August 2005 at UTM coordinates 577297 easting by 5556782 northing (UTM zone 11, NAD83 datum). There were no records indicating use of Johnson Lake by a female or family group. At TTCAS, multiple entrances and extensive trampling suggested that a burrow complex at 587684 easting by 5506495 northing was used as maternal den in 2006.

3.2 Field-Based Badger and Ground Squirrel Sampling

The density of total ground squirrel burrows (recent and old combined) varied by only about 21% among the 3 WHAs (Table 2). However, the density of total badger burrows was almost 3 times higher at Johnson Lake than Fir Mountain, and the density of recent badger burrows (corrected for survey date) was over 7 times greater at Johnson Lake than Fir Mountain, with Ta Ta Creek Airport South being intermediate in both cases (Table 2). Correspondingly, a lower proportion of the badger burrows observed at Fir Mountain had been recently occupied in comparison to the other WHAs, and the ratio of badger to ground squirrel burrows was also lower at Fir Mountain. The true ratio of recent to total ground squirrel burrows could not be determined because they were classified only by 50-m segment rather than each burrow (i.e. if any ground squirrel burrows in a segment were recent, the entire segment was classified as recent ground squirrel burrows, due to the time requirement and difficulty of classifying every ground squirrel burrow). Within that constraint, it appeared that a lower proportion of ground squirrel burrows at the TTCAS WHA was recent, compared to the other WHAs (Table 2).

Table 2. Columbian ground squirrel and badger burrow densities at 3 badger wildlife habitat areas in the East Kootenay area of British Columbia, 2006.

WHA	Mean Survey Date	Burrow Density (/ha)					
		Ground Squirrels			Badgers		
		Recent[1]		Total	Recent[1]		Total
		Observed	Corrected[2]		Observed	Corrected[2]	
Fir Mountain	11 Jun	114.6	129.8	121.1	1.6	2.0	5.9
Johnson Lake	17 Jul	111.6	116.7	114.7	12.4	14.5	16.1
TTCAS	23 Aug	78.8	78.8	100.1	5.5	6.1	10.9

[1] for ground squirrels, if at least 1 burrow per transect segment was recent, all burrows per segment were included in tabulation of recent burrows (each burrow not classified)
[2] P_{max} = predicted (standardized) number of recent burrows by end of season (Appendix 1)

In general, ground squirrels burrows were relatively evenly distributed within each WHA, and in most segments having burrows there was at least one recent burrow (Figures 3 - 8). This was less true for TTCAS, in which significant areas in the north-central and southeastern portions of the WHA lacked ground squirrel burrows or at least had no recent ones. There were no visually obvious trends relating to the cover types where ground squirrel burrows were located, either within or among WHAs; all 4 classes of crown closure among forested polygons plus open range and cultivated areas supported ground squirrel burrows (Figures 3 - 8). There was only one small polygon having >45% crown closure (at TTCAS). It appeared to have a slightly lower burrow density than many of the polygons of lower crown closure, considering the 3 WHAs collectively. However, it was of limited size and there were areas of more open forest at TTCAS that also had low ground squirrel burrow densities. Similarly, while the WHA with the greatest proportion of forest (TTCAS) had the lowest ground squirrel density, the lack of trend relative to forest cover within TTCAS makes the validity of any such relationship questionable.

Badger burrow densities patterns were closely related to those of ground squirrels burrows, albeit with a slightly less uniform distribution. Therefore, badgers showed no clear affiliation to particular cover types. The patterns of recent and total badger burrows showed high spatial concordance, suggesting that recent badger activity occurred in much the same area as previous badger activity (Figures 9 - 14).

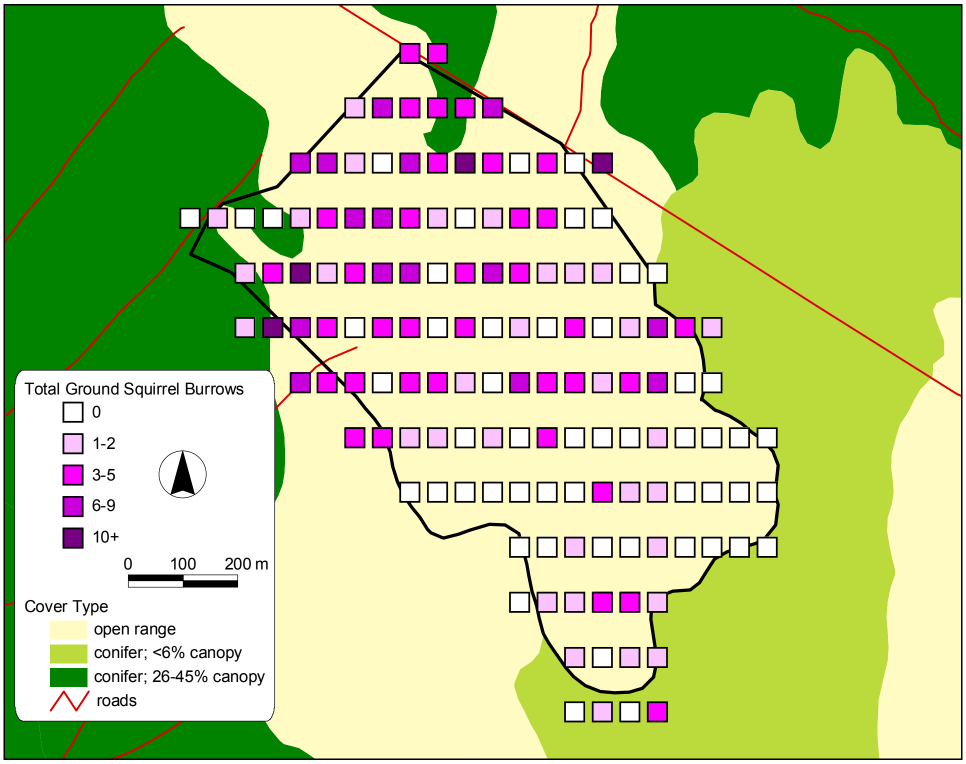

Figure 3. Ground squirrel burrows recorded by transect segment, Fir Mountain WHA, 2006. Numbers have not been corrected in relation to survey date.

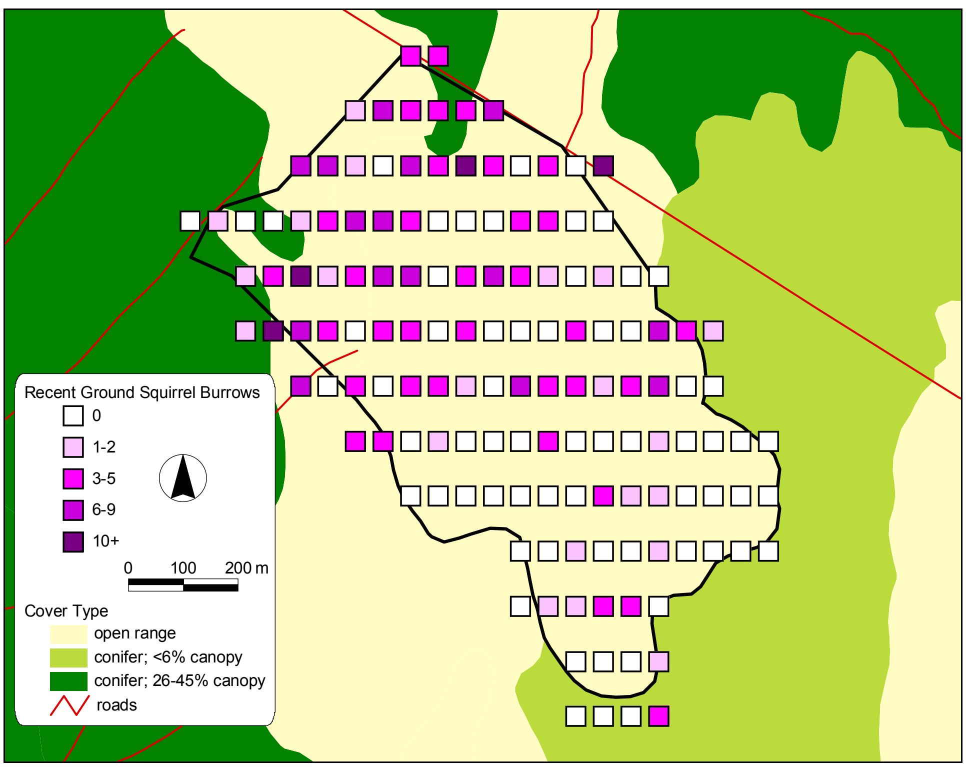

Figure 4. Ground squirrel burrows recorded on transect segments for which at least 1 burrow had been recently occupied, Fir Mountain WHA, 2006. Numbers have not been corrected in relation to survey date.

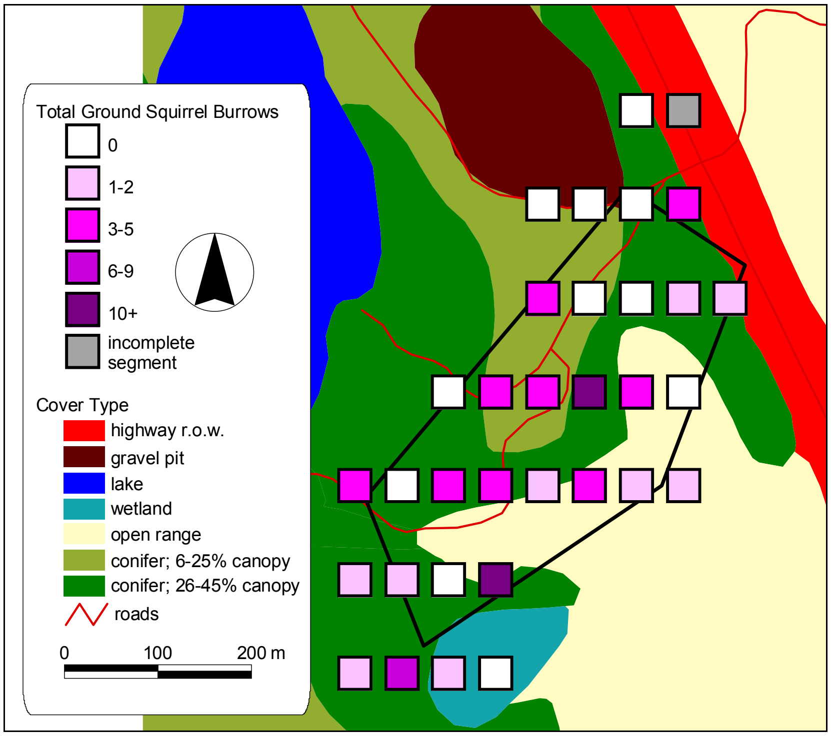

Figure 5. Ground squirrel burrows recorded by transect segment, Johnson Lake WHA, 2006. Numbers have not been corrected in relation to survey date.

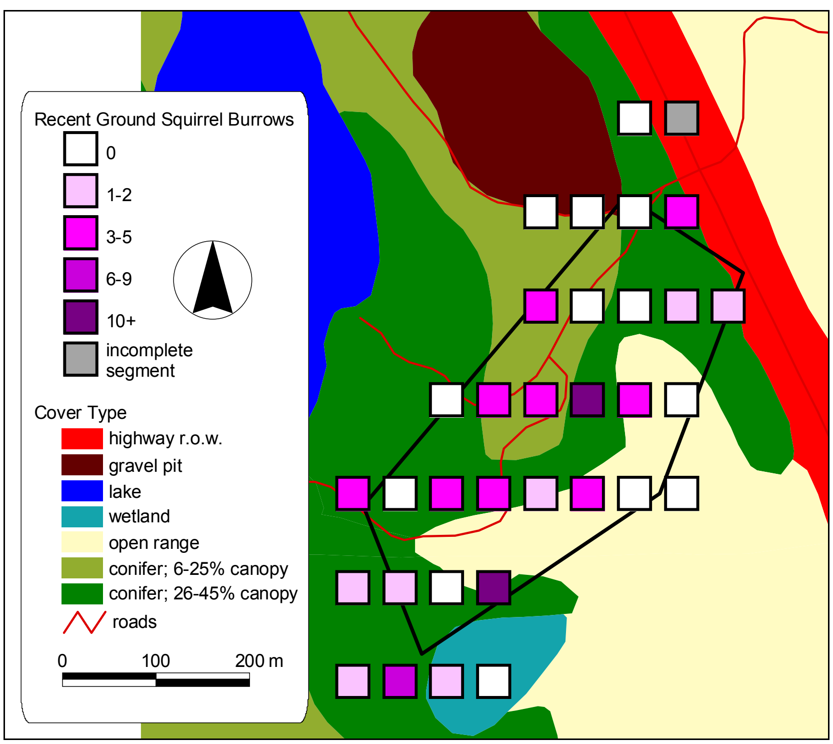

Figure 6. Ground squirrel burrows recorded on transect segments for which at least 1 burrow had been recently occupied, Johnson Lake WHA, 2006. Numbers have not been corrected in relation to survey date.

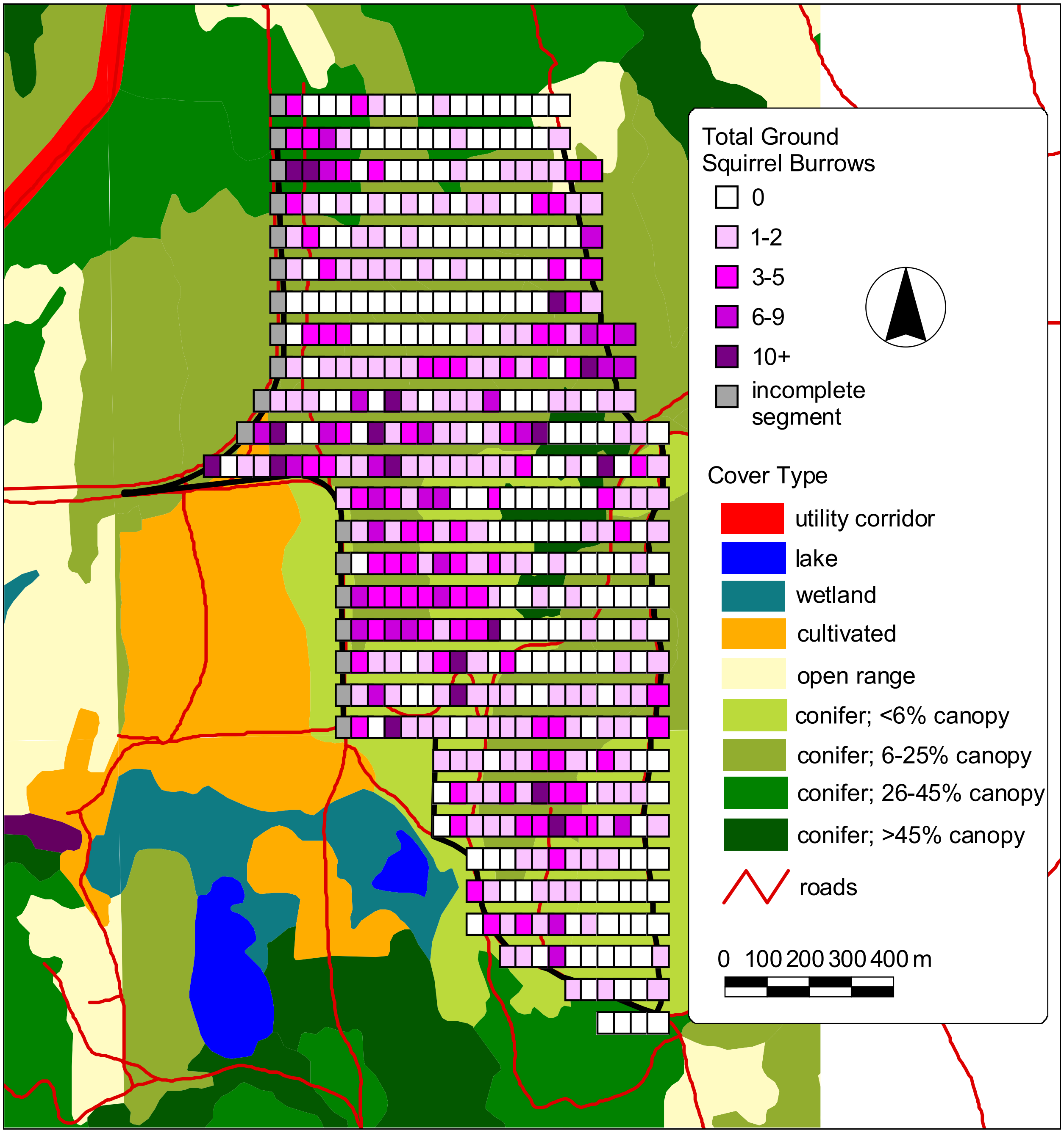

Figure 7. Ground squirrel burrows recorded by transect segment, Ta Ta Creek Airport South WHA, 2006. Numbers have not been corrected in relation to survey date.

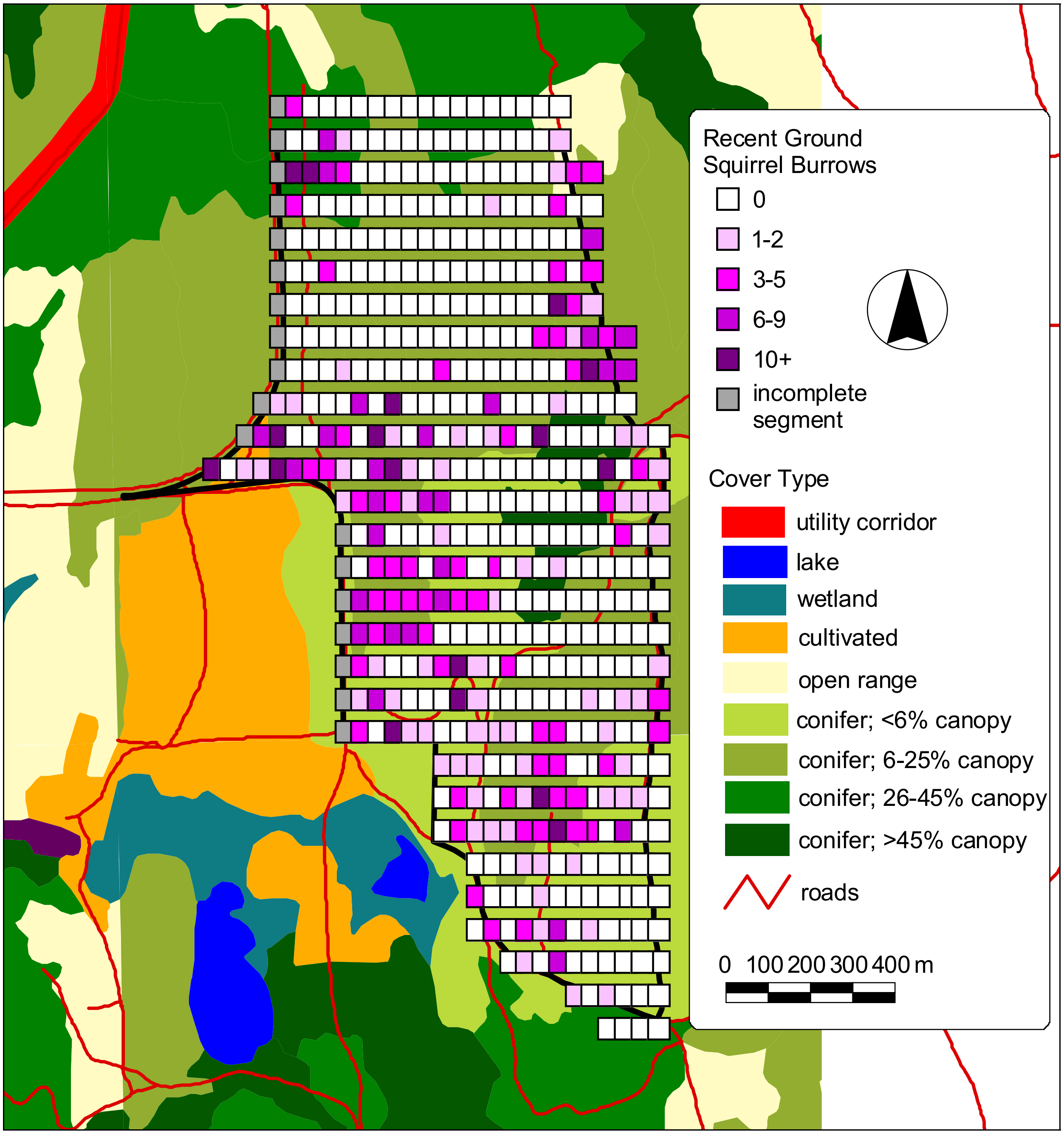

Figure 8. Ground squirrel burrows recorded on transect segments for which at least 1 burrow had been recently occupied, Ta Ta Creek Airport South WHA, 2006. Numbers have not been corrected in relation to survey date.

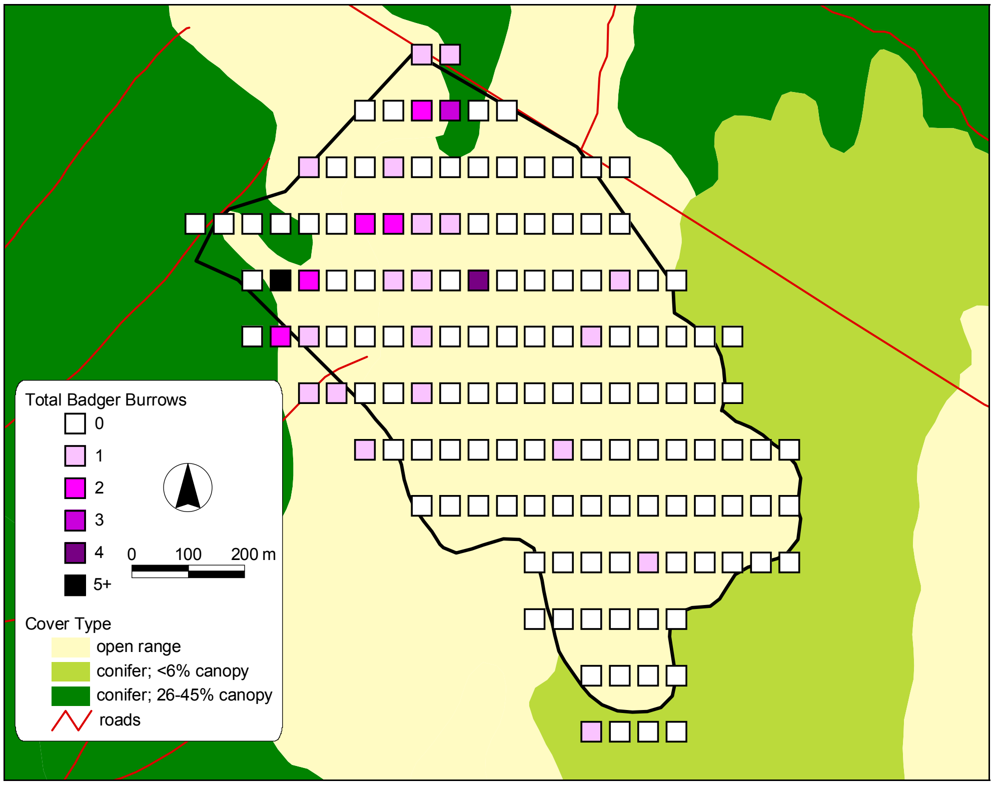

Figure 9. Total badger burrows recorded by transect segment, Fir Mountain WHA, 2006. Numbers have not been corrected in relation to survey date.

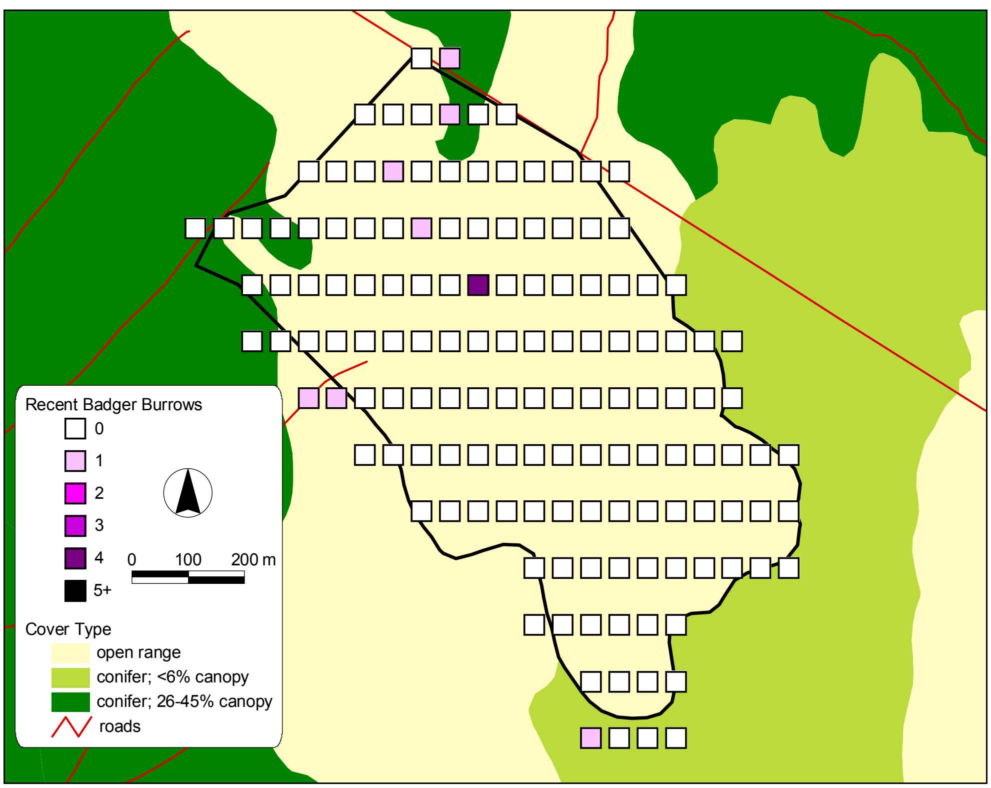

Figure 10. Recent badger burrows recorded by transect segment, Fir Mountain WHA, 2006. Numbers have not been corrected in relation to survey date.

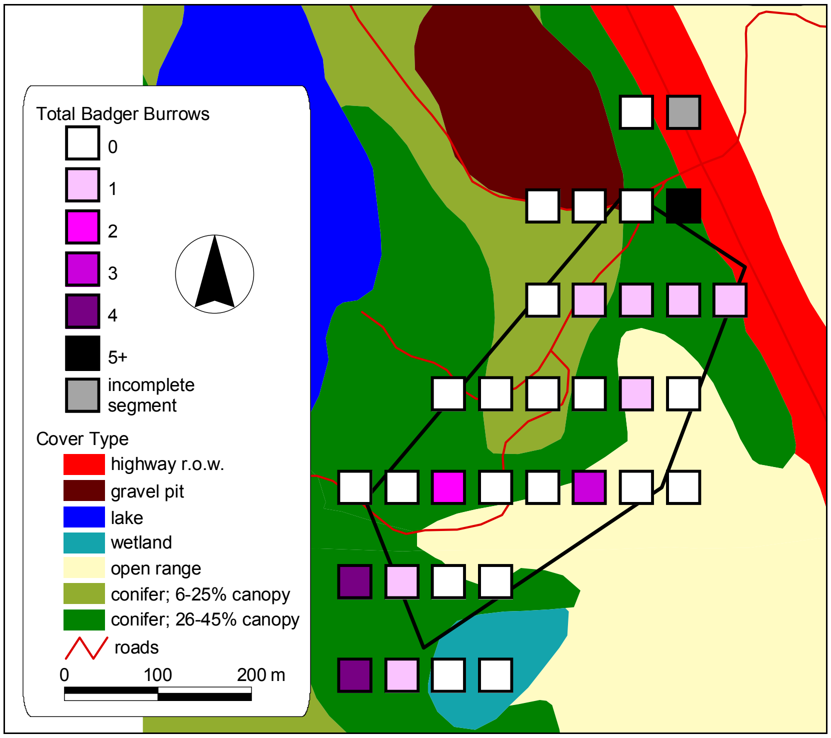

Figure 11. Total badger burrows recorded by transect segment, Johnson Lake WHA, 2006. Numbers have not been corrected in relation to survey date.

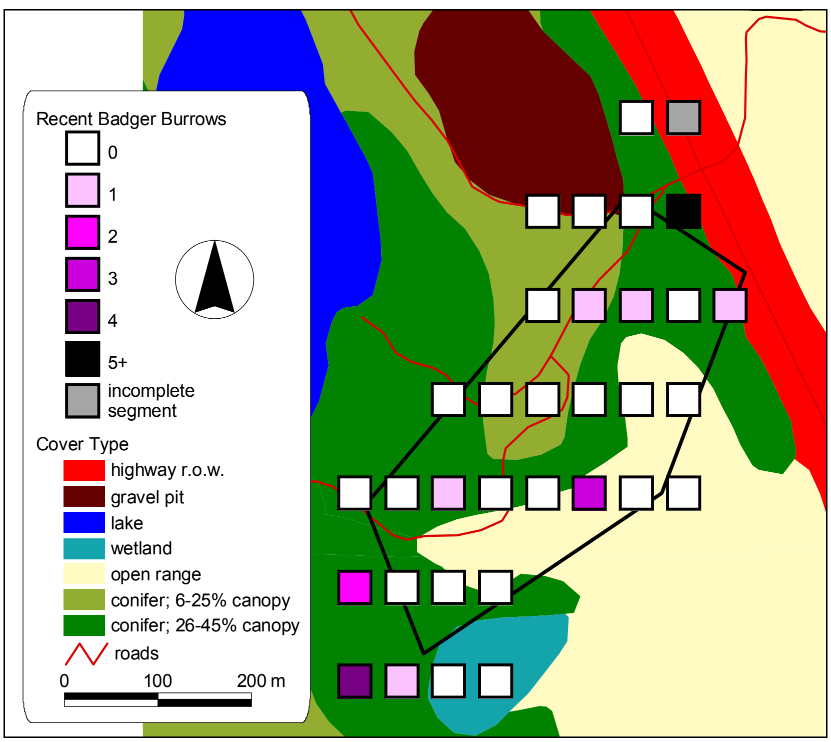

Figure 12. Recent badger burrows recorded by transect segment, Johnson Lake WHA, 2006. Numbers have not been corrected in relation to survey date.

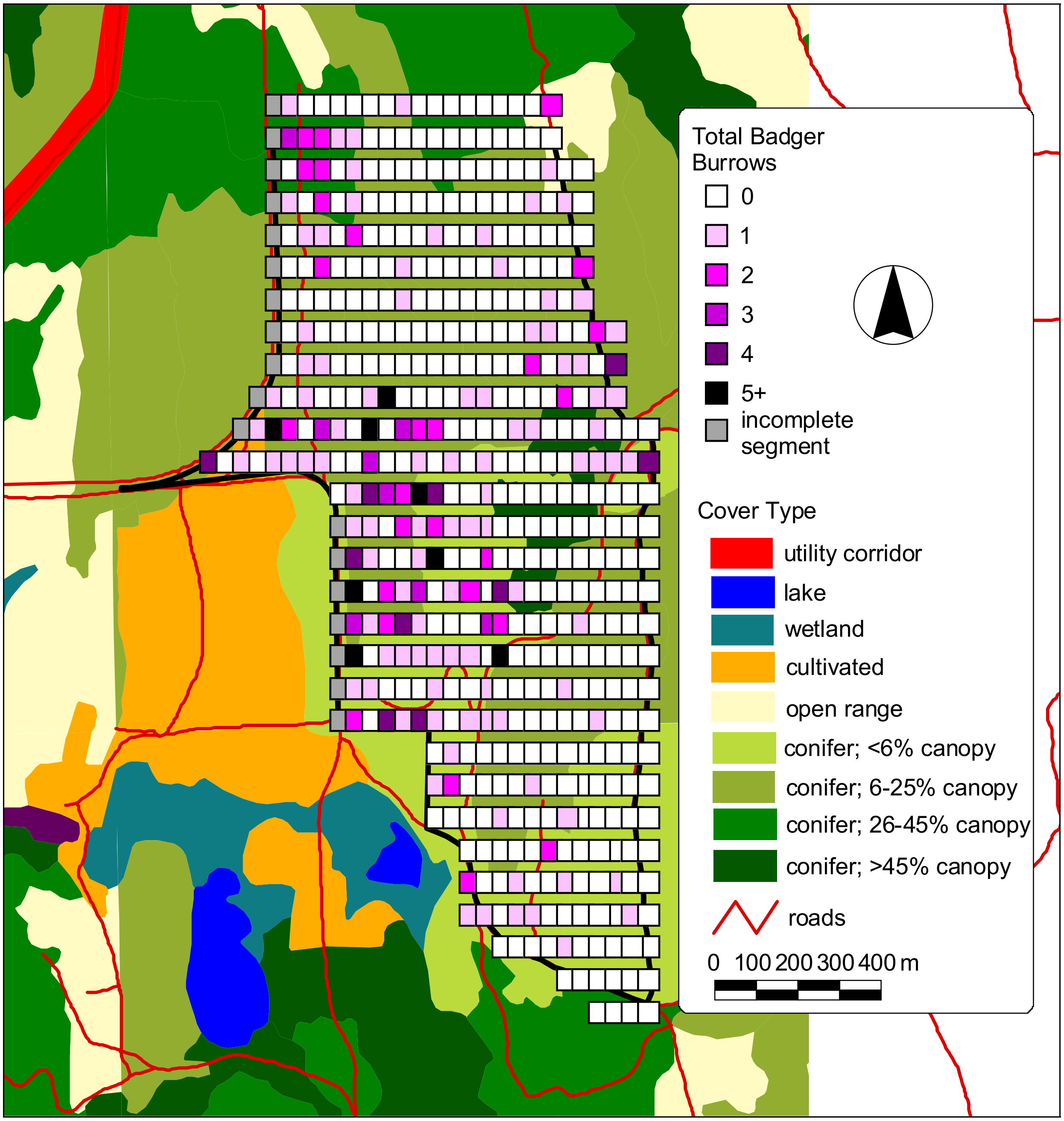

Figure 13. Total badger burrows recorded by transect segment, Ta Ta Creek Airport South WHA, 2006. Numbers have not been corrected in relation to survey date.

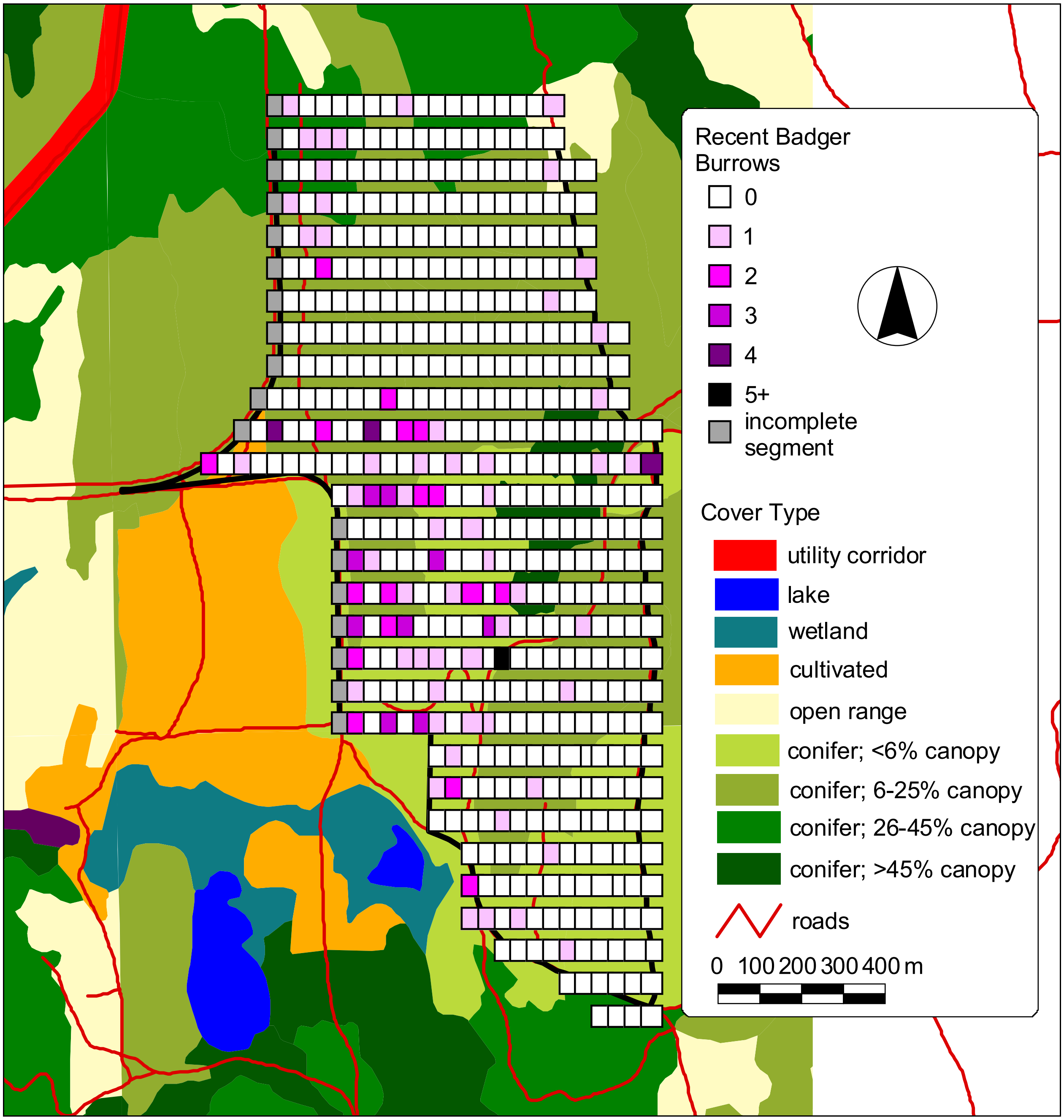

Figure 14. Recent badger burrows recorded by transect segment, Ta Ta Creek Airport South WHA, 2006. Numbers have not been corrected in relation to survey date.

3.3 Baseline Burrow Densities

Densities of both ground squirrel and badger burrows were intermediate at the WHAs in comparison to the low-density random plots and the high-density areas near burrows of radiotagged badgers (Table 3).

Table 3. Columbian ground squirrel and badger burrow densities determined through 3 types of field sampling in the East Kootenay area of British Columbia, 2006.

Source	Year	n	Burrow Density (/ha)			
			Ground Squirrels		Badgers	
			P_{max}[1]	Total	P_{max}[1]	Total
random plots in IDF[2]	1998	201 plots		4.1		0.9
burrows of tagged badgers[2]	1996-2000	397 burrows		154.6		88.0
WHAs	2006	3 WHAs	108.4	111.9	7.5	11.0

[1] P_{max} = predicted (standardized) number of recent burrows by end of season (Appendix 1)
[2] N. Newhouse, Sylvan Consulting Ltd., unpubl. data

We assume that transects conducted at the burrows of tagged badgers (Table 3) fall within high-quality habitat, as represented by ground squirrel abundance, and that random plots in the IDF represent the average condition in the East Kootenay. Therefore, we propose that the "high" stratum of ground-squirrel burrow density should include WHAs having a density of at least the arithmetic mean of densities from random sites and the best habitat. Because this value (79.35/ha) is based on total, rather than recent, burrows, we adjust it using the ratio of P_{max} to total ground squirrel burrows observed in WHAs (Table 3). This translates to 76.86 ground squirrel burrows/ha (P_{max}) occurring in transect segments having at least some recent ground squirrel activity. For simplicity, we round this to preliminarily define a high density of recent ground squirrel burrows as being a P_{max} of 75/ha. All 3 WHAs investigated therefore exceed this criterion and can be defined as having a high density of recent ground squirrel burrows.

For badgers, transects conducted at the burrows of tagged animals presumably represent the best habitat, but in fact are characterized by an unrealistically high density of badger burrows, even for high-quality habitat. This is because the transect locations were defined by the presence of badger burrows. Owing to the clumped distribution of burrows, badger burrow density in the immediate vicinity of other badger burrows would be much higher than could be sustained over an area the size of a WHA. Thus, we propose that the "high" stratum of badger burrow density should include WHAs having a density of at least the geometric (rather than arithmetic) mean of densities from random transects and transects originating at badger burrows. Adjusting this value (8.9/ha) using the ratio of P_{max} to total badger burrows observed in WHAs (Table 3) this translates to a threshold P_{max} of 6.07 burrows/ha. For simplicity, we round this to preliminarily define a high density of recent badger burrows as being a P_{max} of at least 6/ha. The Johnson Lake and TTCAS WHAs met or exceeded this criterion but the Fir Mountain WHA did not.

It should be noted that the degree to which a WHA is likely to be classified as having a high density of recent badger or ground squirrel burrows is in part related to the WHA's size. Larger WHAs are more likely to take in pockets of non-habitat or poor habitat. It is therefore less likely that the threshold P_{max} will be achieved as regularly at large WHAs as at smaller ones.

4. Assessments Related to Risk

Centroid coordinates used in calculating the area of permanent habitat loss (4.1.3), change in percent canopy closure (4.1.4) and road densities within WHAs (4.2.4) are reported in Appendix 2. These must be used for future assessments to ensure that analysis areas are consistent among years.

4.1 Habitat-Related Assessments

4.1.1 Rapid On-site Assessment

Rapid assessments were not formally conducted at the WHAs, although the fieldwork conducted at them provided an opportunity to achieve the goal of such assessments, i.e. to observe any management issues not otherwise apparent from other measures of WHA risk. There were no noteworthy management issues evident at any of the 3 WHAs.

4.1.2 Range Condition

In relation to range health assessments, recent ground squirrel and badger burrows did not follow any obvious distribution trend at Fir Mountain or Johnson Lake (Figures 15 - 18). At TTCAS, the segments with greater ground squirrel and badger burrow densities were disproportionately in polygons having “healthy with problems” rather than “healthy” ratings (Figures 19 - 20). The lack of diversity in grazing intensity within the Johnson Lake and Fir Mountain WHAs makes comparisons across intensities difficult (Figures 15 - 18). At TTCAS, recent ground squirrel and badger burrows were disproportionately in polygons with higher grazing intensities (Figures 19 - 20), corresponding largely to the “healthy with problems” assessment areas described above.

Other range characteristics are summarized in the Excel files Fir Mountain Range Inventory.xls, Johnson Lake Range Inventory.xls and TaTa Airport South Range Inventory.xls. Those files also include photos taken from each range plot. Among 19 polygons for which a range assessment was conducted within the 3 WHAs, the leading grass species included pinegrass (9 plots), spreading needlegrass (4), orchardgrass (2), quackgrass (1), Junegrass (1), rough fescue (1), and Idaho fescue (1). The leading forb species was highly variable, including timber milk-vetch (3 plots), yellow penstemon (3), black medic (3), yarrow (2), spikelike goldenrod (2), alfalfa (1), sulphur cinquefoil (1), nodding onion (1), Scouler’s hawkweed (1), yellow hedysarum (1), and old man’s whiskers (1). Shrubs were absent in 2 plots; where present, the leading shrub species were kinnikinnick (8 plots), birch-leaved spirea (3), antelope-brush (2), soopolallie (1), prickly rose (1), trembling aspen (1), and Douglas-fir (1). All common names follow usage in E-Flora BC (http://www.eflora.bc.ca/; accessed 2 March 2007).

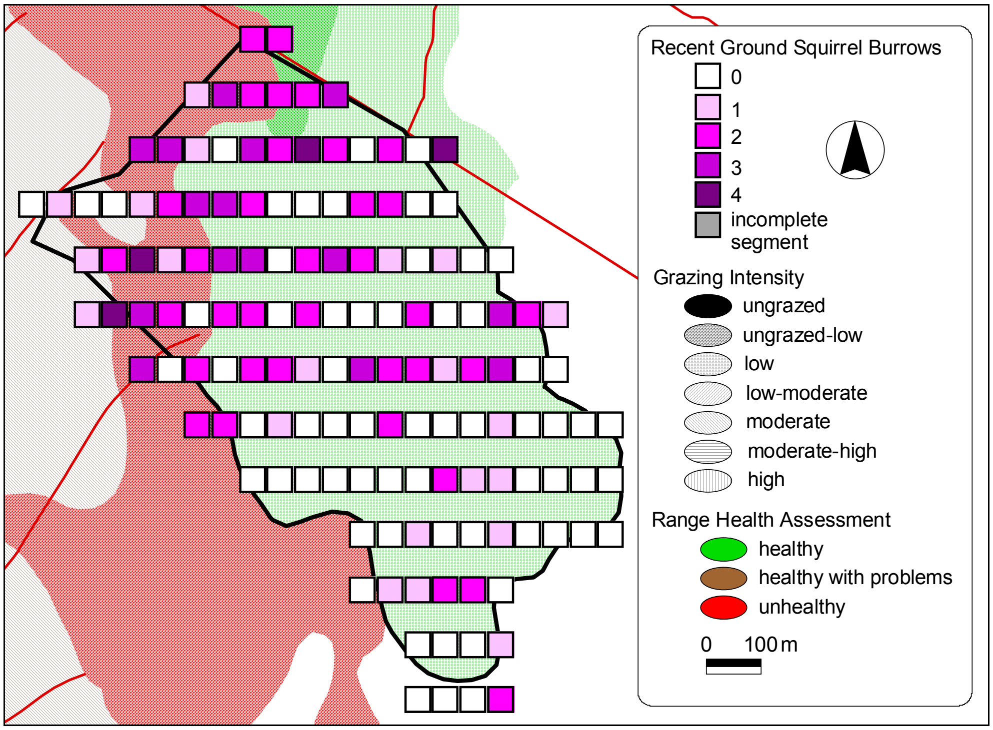

Figure 15. Recent ground squirrel burrows in relation to range condition, Fir Mountain WHA, 2006. Numbers have not been corrected in relation to survey date.

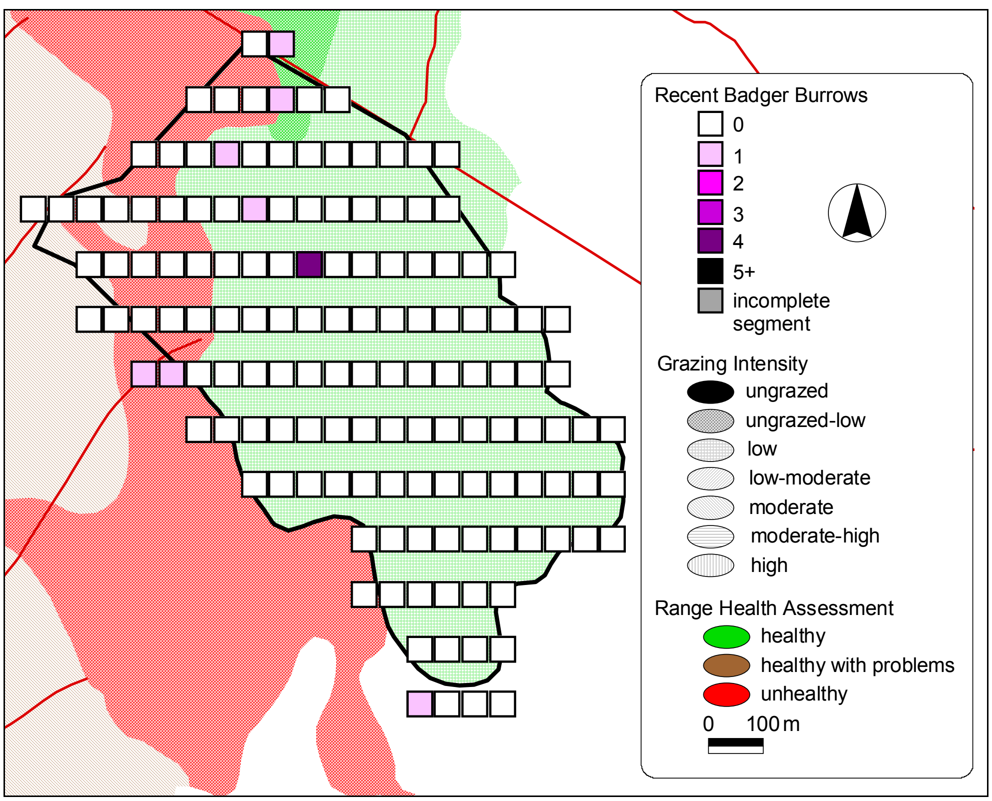

Figure 16. Recent badger burrows in relation to range condition, Fir Mountain WHA, 2006. Numbers have not been corrected in relation to survey date.

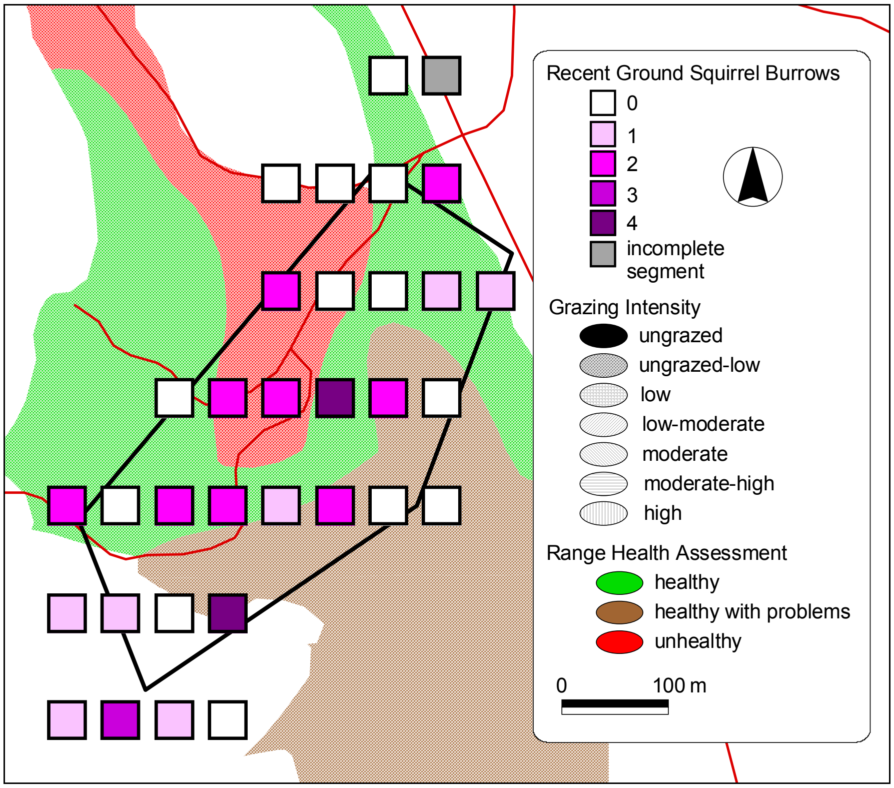

Figure 17. Recent ground squirrel burrows in relation to range condition, Johnson Lake WHA, 2006. Numbers have not been corrected in relation to survey date.

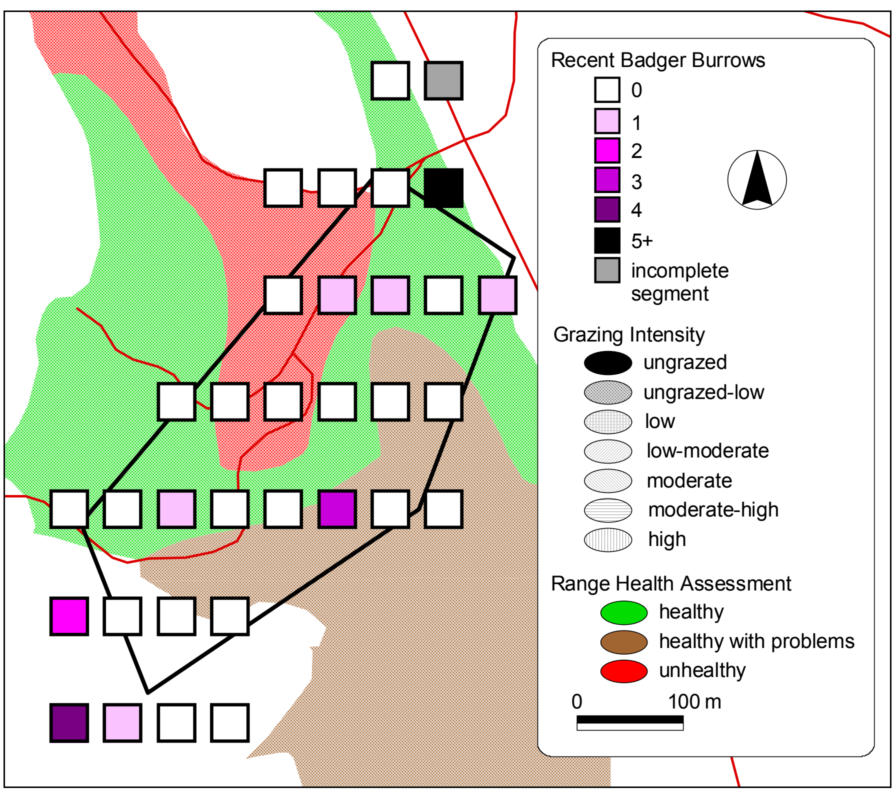

Figure 18. Recent badger burrows in relation to range condition, Johnson Lake WHA, 2006. Numbers have not been corrected in relation to survey date.

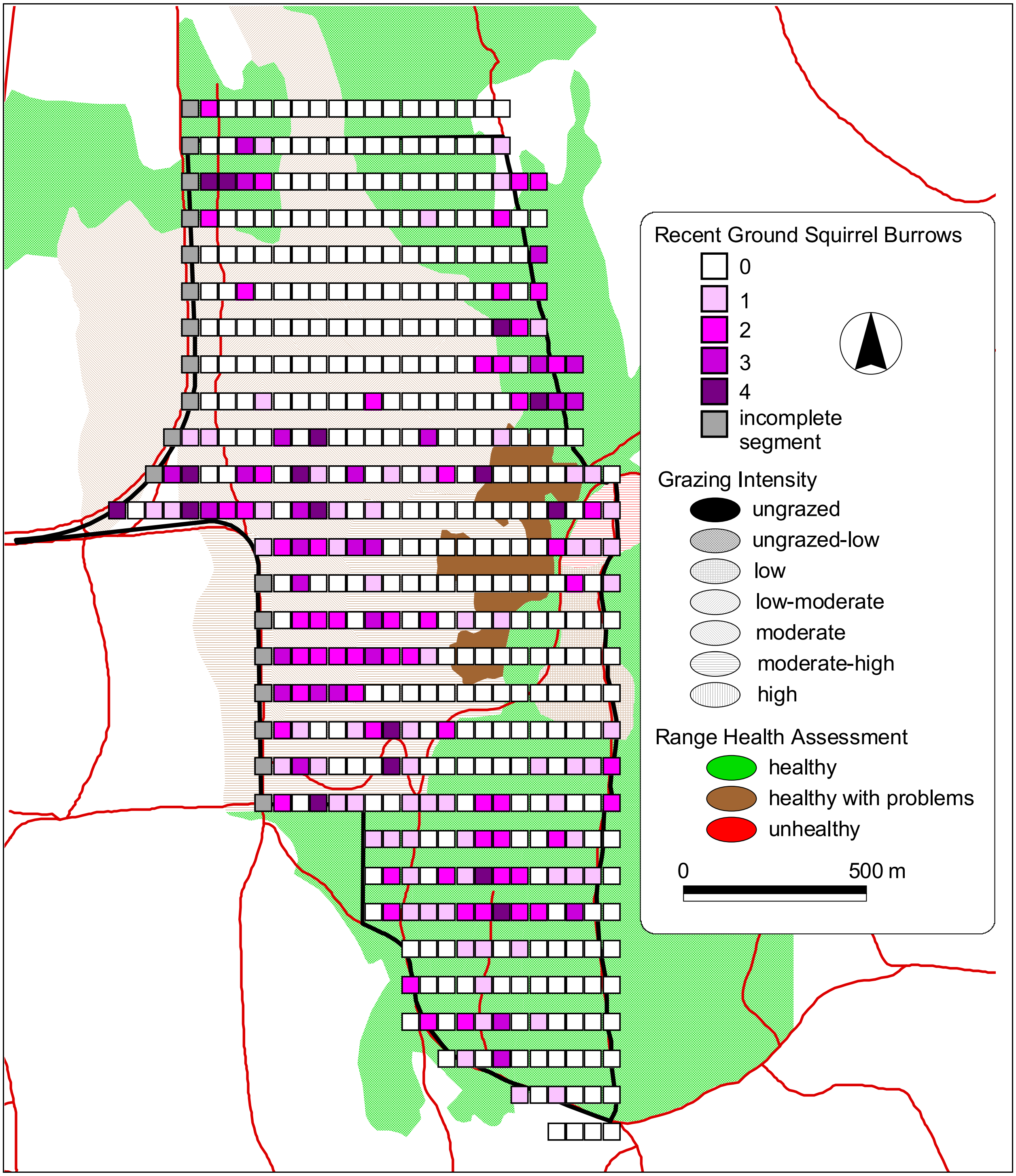

Figure 19. Recent ground squirrel burrows in relation to range condition, Ta Ta Creek Airport South WHA, 2006. Numbers have not been corrected in relation to survey date.

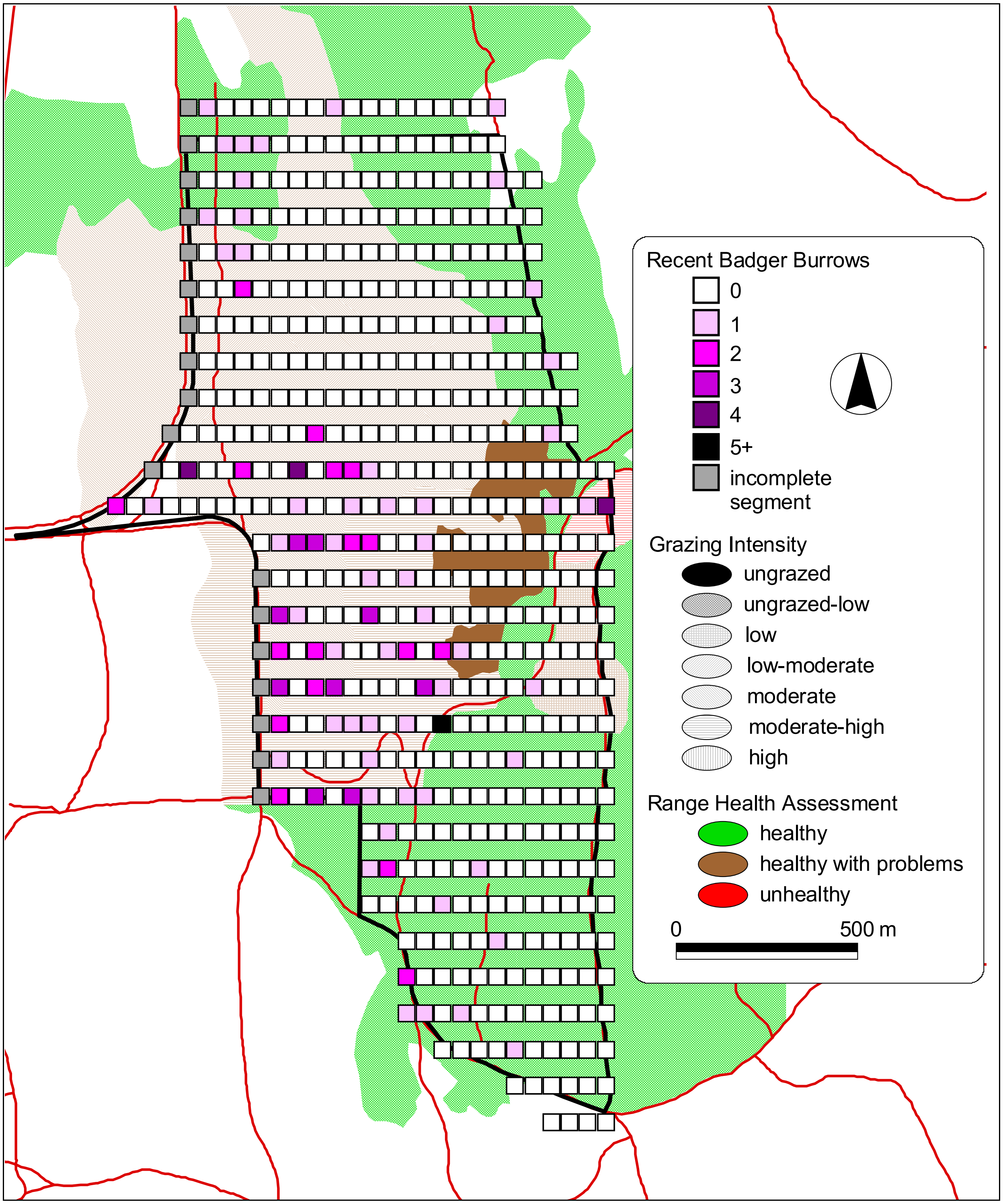

Figure 20. Recent badger burrows in relation to range condition, Ta Ta Creek Airport South WHA, 2006. Numbers have not been corrected in relation to survey date.

4.1.3 Area of Permanent Grassland Habitat Loss

No trends in habitat loss could be calculated because 2006 was the first year of analysis, but recent conditions were established as a baseline using map data produced by the Grasslands Conservation Council (GCC). There had been essentially no conversion of historic grassland to other cover types within any of the WHAs, or near Fir Mountain (Table 4). At Johnson Lake, nearly 1/5 of the classified historic grasslands in the 1-km-radius circle had been converted to the urban category, and about 1/10 of the 3-km circle had been converted to urban or clearings, although the large proportion of unclassified grassland or developed grassland makes this conclusion less certain. At TTCAS, only a small portion of the WHA and surrounding area was considered to be historic grassland, so results indicating considerable conversion to clearings (Table 4) may be of less consequence.

4.1.4 Change in Percent Canopy Closure

No trends in habitat loss could be calculated because 2006 was the first year of analysis, but recent conditions were established as a baseline (Figure 21). At Fir Mountain, forest (and potential forest) in and surrounding the WHA had very low crown closure. Crown closure at Johnson Lake was also low, though somewhat higher in the WHA than in the surrounding areas. In the TTCAS WHA, crown closures were relatively evenly split among the low to moderate categories, with the WHA quite similar to circles of 1 and 3 km surrounding it.

4.2 Mortality-Related Assessments

4.2.1 Road Mortalities

No badger road mortalities falling with 3 km of any of the 3 WHAs were recorded through the Badger Hotline, *jeffersonii* Badger Recovery Team website, or the East Kootenay badger project from 6 October 2000 through 6 October 2006.

4.2.2 Adjacency of Burrows to Highways

No part of the Fir Mountain WHA is within 200 m of a paved road. The northeastern portion of the Johnson Lake WHA abuts Highway 93/95, and the western edge of TTCAS borders Highway 95A at the north and Mission Road for part of the south.

At Johnson Lake, disregarding partial transect segments, those within 200 m of these roads included 1-1, 2-1 to 2-4, 3-2 to 3-5, 4-5, 4-6 and 5-8. Six of 12 segments (50%) within 200 m of the highway had badger burrows, compared to 6 of 20 (30%) for the others segments. Thus, it appeared that a disproportionately high number of segments having badger burrows were within 200 m of the highway, but this was not statistically significant (Pearson $\chi^2 = 1.28$, $P = 0.26$).

At TTCAS, disregarding partial transect segments, those within 200 m of these roads included the second to fourth segments of transects 1 through 10 and 14 through 20, and 11-2 to 11-8, 12-1 to 12-11, 13-1 to 13-4. Forty-two of 73 segments (58%) within 200 m of the highway had badger burrows, compared to 109 of 424 (26%) for the others segments. Therefore, a disproportionately high number of segments containing badger burrows were within 200 m of paved roads (Pearson $\chi^2 = 29.83$, $P < 0.001$).

Table 4. Developed grassland in 3 WHAs and in circles of 1- and 3-km radii from WHA centroids, in relation to remaining grassland. Values include only areas classified by GCC mapping as "grassland" or "developed grassland". Within areas classified as developed grasslands, classification as urban or clearing is based on a combination of GCC mapping and VRI mapping. Blanks signify 0%.

WHA	Category	Area (ha)		
		Within WHA	Within 1 km	Within 3 km
Fir Mountain	*Total Area (ha)*	*59.00*	*314.00*	*2827.00*
	Area Mapped[1] (ha)	57.43	247.76	1316.11
	Grassland & Associated (%)	100.00	100.00	99.84
	open grassland	98.59	58.72	52.14
	open, dry forest		23.56	10.24
	burned or logged			0.25
	brush or meadow			2.19
	broken terrain, rock or clay			2.61
	conifer forest			0.39
	deciduous forest	1.41	17.72	31.38
	Developed Grassland (%)	0.00	0.00	0.16
	urban[2]			0.16
	No descriptor (%)	0.00	0.00	0.23
Johnson Lake	*Total Area (ha)*	*9.41*	*314.00*	*2827.00*
	Area Mapped[1] (ha)	9.41	240.92	1783.21
	Grassland & Associated (%)	28.24	33.19	39.33
	open grassland	28.24	33.19	15.08
	open, dry forest			12.78
	burned or logged			9.70
	brush or meadow			0.66
	broken terrain, rock or clay			0.62
	deciduous forest			0.49
	Developed Grassland (%)	0.53	7.85	4.09
	clearings			1.31
	urban[2]	0.53	7.85	2.78
	No descriptor (%)	71.23	58.96	56.58
TTCAS	*Total Area (ha)*	*225.26*	*314.00*	*2827.00*
	Area Mapped[1] (ha)	21.96	85.11	827.40
	Grassland & Associated (%)	90.30	58.01	80.51
	open grassland	4.14	0.01	35.87
	open, dry forest	86.16	57.98	27.90
	burned or logged			11.68
	brush or meadow			2.50
	deciduous forest			2.56
	Developed Grassland (%)	9.70	41.99	18.98
	clearings	9.70	41.99	14.99
	urban[2]			3.98
	No descriptor (%)	0.00	0.00	0.51

[1] grasslands, developed grasslands and areas within "grassland" map layer lacking descriptor
[2] includes roads, roadsides, gravel pits, etc.

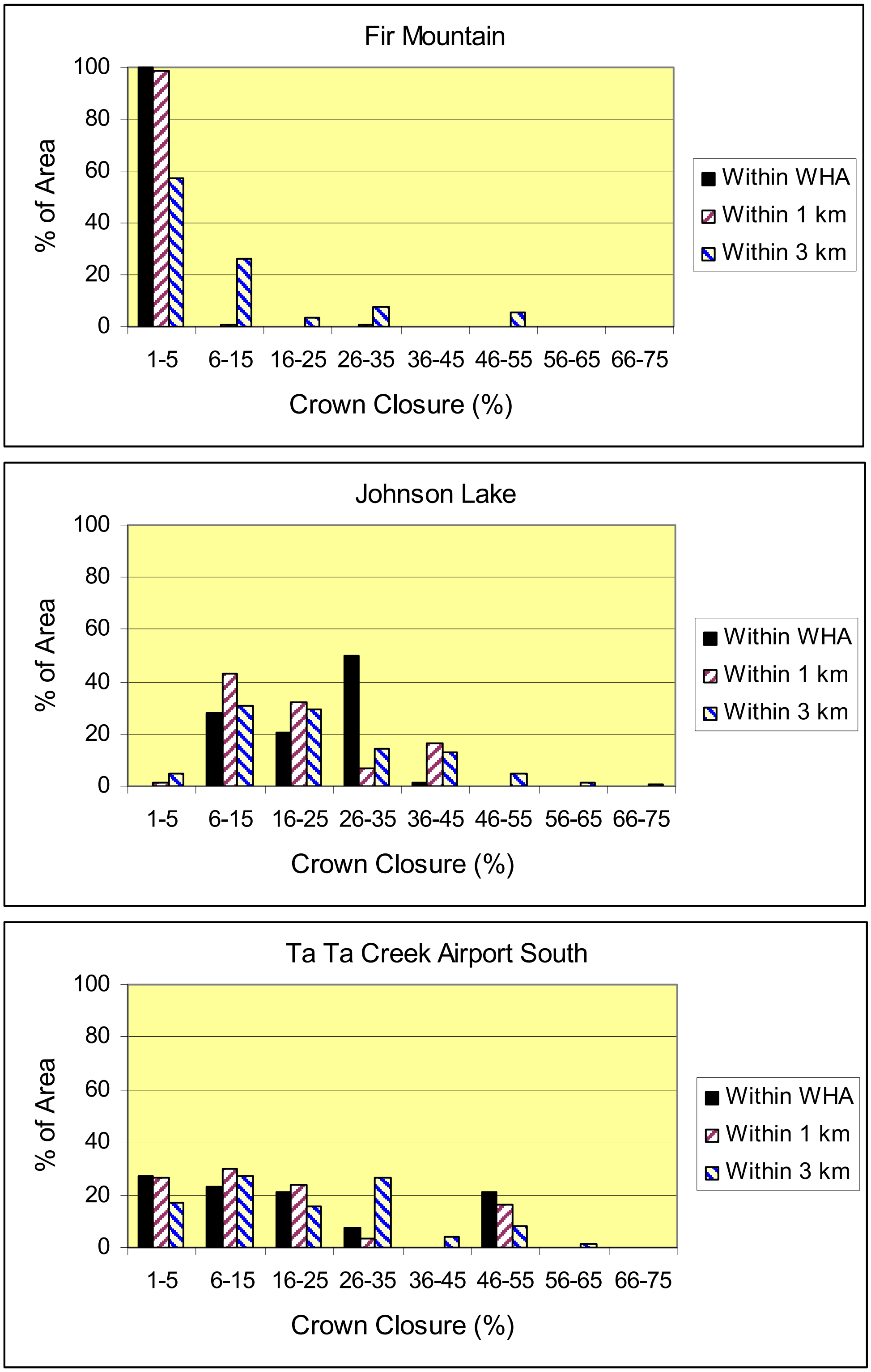

Figure 21. Crown closure classes for forest cover polygons identified as having crown closure (excludes non-forested polygons) in WHAs and in circles of 1-km and 3-km radii around WHA centroids.

4.2.3 Traffic Volume on Adjacent Highways

There are no paved roads in or near the Fir Mountain WHA, but highways 93/95 and 95A abut the Johnson Lake and TTCAS WHAs respectively. No traffic volume data are available for any portion of Highway 95A, nor for segments of Highway 93/95 near Johnson Lake (http://www.th.gov.bc.ca/trafficData/tradas/inset3.asp accessed 20 February 2007). Highway 93/95 data are available from just north of the Fort Steele interchange north of Cranbrook and at Radium Hill Road just south of Radium Hot Springs. The Radium data are likely to grossly overstate the traffic volume at Johnson Lake owing to the Alberta-Columbia Valley traffic flow. The Fort Steele interchange data (traffic counter site P-35-2NS) are also likely to considerably overstate the volume of traffic reaching Johnson Lake because much traffic goes from Cranbrook or points east to Fort Steele, Wasa and the Skookumchuck pulp mill, stopping short of Johnson Lake. However, these data may be somewhat closer to values at the WHA so are considered here.

Within the spring, summer and fall, daily volumes at P-35-2NS for 2005 and 2006 ranged from 2582 in November 2005 to 5073 in August 2006 (both directions combined). It is unclear what proportion of those vehicles also passed by the Johnson Lake WHA, but it seems likely that the number exceeded the 1000/day identified in the WHA protocol document as the threshold for causing significant badger risk.

4.2.4 Road Densities

The density of roads varied considerably among WHAs (Table 5). Fir Mountain had the lowest density of roads by any of the measures, with the difference greatest within the WHA and much less apparent in the 3-km radius. Johnson Lake had more roads than TTCAS within the WHA, but slightly fewer at the 1- and 3-km radii. Of the 3 WHAs and 3 scales, the highest proportion of paved roads was at Johnson Lake for the 3-km radius. For use under possible future changes to the assessment protocol, the actual road segment lengths are indicated in Table 6.

Table 5. Density of roads in 3 WHAs and in circles of 1- and 3-km radii from WHA centroids.

WHA	Road	Road Density (km/km^2)		
	Type	Within WHA	Within 1 km	Within 3 km
Fir Mountain	Paved	0.000	0.000	0.000
	Gravel	0.290	1.065	1.684
	Trail	0.000	0.486	0.162
	Total	0.290	1.550	1.846
Johnson Lake	Paved	0.000	0.628	1.743
	Gravel	9.869	1.862	0.215
	Trail	0.000	0.000	0.002
	Total	9.869	2.490	1.960
TTCAS	Paved[1]	0.325	0.781	0.373
	Gravel	2.277	2.340	2.374
	Trail	0.000	0.000	0.028
	Total	2.602	3.121	2.775

[1] Paved roads abut TTCAS but are not actually within it. The paved-road density shown for the area within TTCAS is presumably a result of imprecise registering of GIS layers.

Table 6. Length of roads in 3 WHAs and in circles of 1- and 3-km radii from WHA centroids.

WHA	Road Type	Road Length (m) Within WHA	Within 1 km	Within 3 km
Fir Mountain	Paved	0	0	0
	Gravel	171	3343	47609
	Trail	0	1525	4573
	Total	171	4868	52182
Johnson Lake	Paved	0	1973	49279
	Gravel	929	5847	6074
	Trail	0	0	43
	Total	929	7820	55396
TTCAS	Paved[1]	732	2453	10558
	Gravel	5129	7348	67105
	Trail	0	0	783
	Total	5861	9801	78445

[1] Paved roads abut TTCAS but are not actually within it. The paved-road length shown for the area within TTCAS is presumably a result of imprecise registering of GIS layers.

5. Effectiveness Ratings

Effectiveness ratings for the 3 WHAs are listed below, based on the measures described above and summarized in Table 7, and with respect to Figure 1 and Table 1. Trends in badger burrow density were unknown because these were first-time assessments, so for the purpose of the flowchart in Figure 1, the trend was assumed to be stable.

Fir Mountain: This site is highly functional due to the presence of a known female within the previous 6 years. Even if a female had not been present, and despite the low density of recent badger burrows, the recent ground squirrel burrow density would have provided the same rating. The risk factors were low to nil. Combining these, the effectiveness rating is 5.

Johnson Lake: Despite there having been no known females or family groups over the previous 6 years, the high density of both ground squirrel and badger burrows yielded highly functional rating. Habitat-related risk factors were low to nil, but roadkill risk factors collectively suggested a long-term risk. This results in an effectiveness rating of 4.

Ta Ta Creek Airport South: This WHA was highly functional because of the presence of a probable maternal den, and even in the absence of such a den, the recent badger and ground squirrel burrow densities would have provided the same rating. Habitat-related risk factors were low to nil, but roadkill risk factors collectively suggested a long-term risk. This results in an effectiveness rating of 4.

Table 7. Summary of functionality and risk measures used in assigning effectiveness ratings to 3 badger WHAs surveyed in the East Kootenay area, 2006. Risk measures highlighted in green relate to habitat; those in yellow relate to mortality risk.

Measure	Rating/Indication		
	Fir Mountain	Johnson Lake	TTCAS
Functionality			
Females, family groups or maternal dens	Yes	No	Yes
Density of recent badger burrows	Low	High	High
Density of recent ground squirrel burrows	High	High	High
Risk (degree of risk indicated)			
Rapid on-site assessment	N/A	N/A	N/A
Range condition[1]	unknown	unknown	unknown
Area of permanent habitat loss[2]	low-nil	low-nil	low-nil
Change in canopy closure[3]	low-nil	low-nil	low-nil
Road mortalities	low-nil	low-nil	low-nil
Adjacency of burrows to highways	low/nil	long-term	immediate
Traffic volume on adjacent highways	low/nil	long-term?	unknown
Road density	low-nil[4]	long-term[5]	long-term[6]

[1] relationship between range condition and risk unknown
[2] recent trend not known (1st year); historic data show little loss of grassland or little proportion of area originally in grassland
[3] recent trend not known (1st year); crown closure roughly the similar within WHA to surrounding 1-km and 3-km-radius circles; effect of moderate canopy closure on badger habitat unclear
[4] based on low density in WHA and moderate density in surrounding landscape
[5] based on high density in WHA but lower density in surrounding landscape
[6] based on moderate densities in WHA and surrounding landscape

6. Literature Cited

Nagorsen, D. W. 2005. Rodents and lagomorphs of British Columbia. The Mammals of British Columbia, Volume 4. Royal BC Museum Handbook. Royal British Columbia Museum, Victoria, British Columbia.

Newhouse, N. J. 1999. Badger habitat and ground squirrel survey summary report. Prepared for Columbia Basin Trust, Nakusp, British Columbia, Columbia Basin Fish and Wildlife Compensation Program, Nelson, British Columbia, and Canadian Parks Service, Radium Hot Springs, British Columbia.

Newhouse, N. J., T. A. Kinley, C. Hoodicoff, and H. Page. 2007. Wildlife habitat area effectiveness evaluations. Protocol for monitoring the effectiveness of badger wildlife habitat areas. Version 1.4. Prepared for Ministry of Forests, Victoria, British Columbia.

Appendix 1: Proposed Method to Standardize the Observed Number of Recently Occupied Ground Squirrel or Badger Burrows in Relation to Survey Date (East Kootenay) Source: Newhouse et al. 2007

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

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

where: R_i = relative number of recent burrows on date t_i
$\log_{10}$ = base 10 log
t_i = date of survey or August 15 (assumed date by which all ground squirrels have entered hibernation), whichever is earlier
t_0 = April 1 (assumed date of emergence from hibernation)
10 = constant added so that R_i on 1 April = 1.000

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

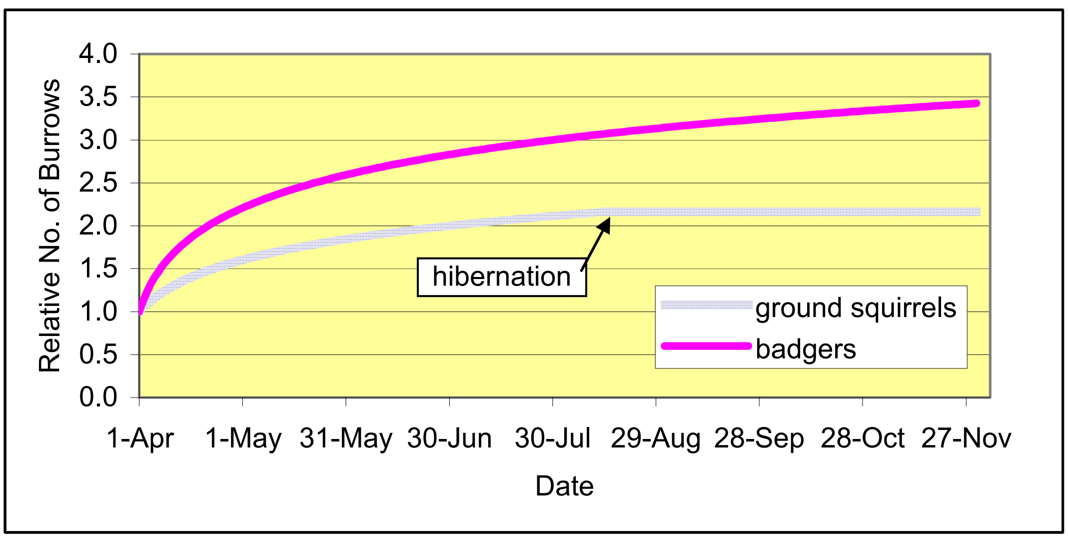

Figure A1. Assumed relationship between date of survey and relative number of recent burrows present.

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

1. Snow cover and freeze-thaw activity will make badger burrows used prior to 31 March indistinguishable from burrows used prior to that calendar year.
2. Badger burrowing activity after 1 April will initially increase rapidly as ground squirrels emerge from hibernation.
3. Burrowing activity will continue to increase throughout the snow-free season. The rate and degree of increase will be greater for badgers than for ground squirrels because badgers are not sedentary and continually create new burrows in hunting for prey. However, the

relationship between badger burrows and time will not be linear because there will be considerable re-use of foraging areas, and some of the existing burrows within them, throughout the summer.

4. This relationship holds true through 30 November, the approximate start date of permanent snow cover.

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

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

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

$\log_5$ = base 5 log (chosen arbitrarily to provide a steeper, higher curve than for ground squirrels)

t_i = date of survey, up to 30 November

t_0 = 1 April

5 = constant added so that R_i on 1 April = 1.000

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

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

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

where: P_{max} = predicted number of recent burrows at end of season (15 August and thereafter for ground squirrels or 30 November for badgers)

N_{obs} = number of burrows observed on date i

R_{max} = relative number of recent burrows on last day of season (greatest possible R_i from previous formulas, i.e. 2.164 for ground squirrels and 3.438 for badgers)

R_i = relative number of recent burrows on survey date t_i (from previous formulas).

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

Appendix 2: WHA Centroid Coordinates and WHA Areas Used in Conducting Some GIS Analyses. Data and figure prepared by Summit Environmental Consultants Ltd., Vernon, British Columbia.

Table A1. Coordinates of centroid points within 3 badger WHAs in the East Kootenay assessed during 2006. UTM coordinates in NAD83 datum. Centroids used for establishing 1- and 3-km-radius circles within which road density, canopy closure and habitat loss are determined in a GIS environment.

WHA	BC Albers		UTM		
	X	Y	Easting	Northing	Zone
Fir Mountain	1718102	622683	577503	5556847	11
Johnson Lake	1732333	601747	588942	5534275	11
Ta Ta Creek Airport South	1734569	574178	587638	5506649	11

Table A2. Area within WHAs and within assessment circles of 1 km and 3 km radii surrounding WHA centroids.

WHA	Area (ha)		
	In WHA	1-km Radius	3-km Radius
Fir Mountain	59.00	314	2827
Johnson Lake	9.41	314	2827
Ta Ta Creek Airport South	225.26	314	2827

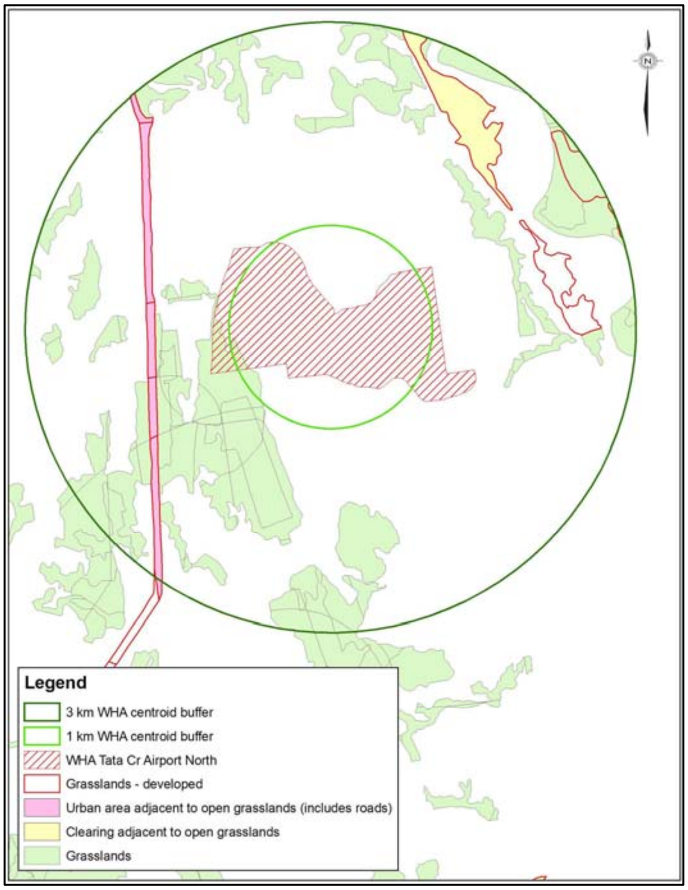

Figure A2. Example of assessment of characteristics within a WHA and 1-km and 3-km-radius circles surrounding its centroid. WHA shown not included in 2006 assessments.