Habitat security for grizzly bears in the Yahk Grizzly Bear Population Unit of the south Purcell Mts. of southeast British Columbia

The Trans-border Grizzly Bear Project

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Introduction - Project rationale and description

The goal of this project is to use research and management to begin recovery efforts of the small fragmented grizzly bear population in the south Purcell Mountains south of BC Highway 3. This trans-border population is threatened in British Columbia (Hamilton et al. 2004) and the US (USFWS 1993) and is the southernmost part of the contracting North American distribution (Mattson and Merrill 2002; Fig. 1). The federal designation for the grizzly bear in Canada is *special concern* (COSEWIC – Committee on the Status of Endangered Wildlife in Canada). Recent research suggests that this is a small (< 50 bears including the US portion, Proctor et al. 2007; Kasworm et al. 2006) declining population (-3.7%/year; Wakkinen and Kasworm 2004) experiencing limited female connectivity with adjacent populations resulting in an elevated conservation risk (Proctor et al. 2005a). This project is part of a larger coordinated effort by the US Fish and Wildlife Service and the BC Ministry of Environment (MoE) for recovery of the south Purcell and south Selkirk populations. While the USFWS has been working on recovery efforts within the US for over a decade, the enhanced efforts within Canada began in 2004.

We, the Trans-border Grizzly Bear Project, use applied scientific research to focus on reducing human-caused mortality, enhancing and re-establishing inter-population connectivity, improving habitat security, and educating the public (Proctor et al. 2004). In working towards our goals, we have completed a spatially-explicit mortality analysis of the region and for the past 2 years have helped hired a Bear Aware specialist to reduce human-caused grizzly bear mortality due to bear-human conflict. We also produced a regional population estimate (Proctor et al. 2007) that has been accepted by the provincial government and has been used to set the Purcell Mt. hunting quotas. Our estimate has also resulted in a hunting closure for grizzly bear in the Wildlife Management Units 4-5 and 4-6, just north of BC Hwy 3 in the Purcell Mts. in an attempt to increase grizzly bear population size and improve linkage across Hwy 3.

The Trans-border Grizzly Bear Project has put considerable effort into improving grizzly bear movement across the Hwy 3 corridor in the Purcell Mts. While this Linkage Project is the topic of a separate report (Proctor et al.2008), we briefly describe it here as it relates to our annual progress and deliverables. We used two methods to accomplish this goal: First, we completed a 2 year DNA survey that culminated in a probability of occurrence model used to predict linkage zones. Tembec FIA funds contributed to that effort. Second, we completed 4 years of radio-collaring to identify areas where bears cross Hwy 3. The radio-collar data identify specific areas where bears cross Hwy 3, are used to validate predictive DNA linkage models, and are used to develop Resource Selection Function (RSF) models. These RSF models are used to identify fine-scale linkage areas as well as to understand habitat use in relation to habitat quality, roads, and other human features.

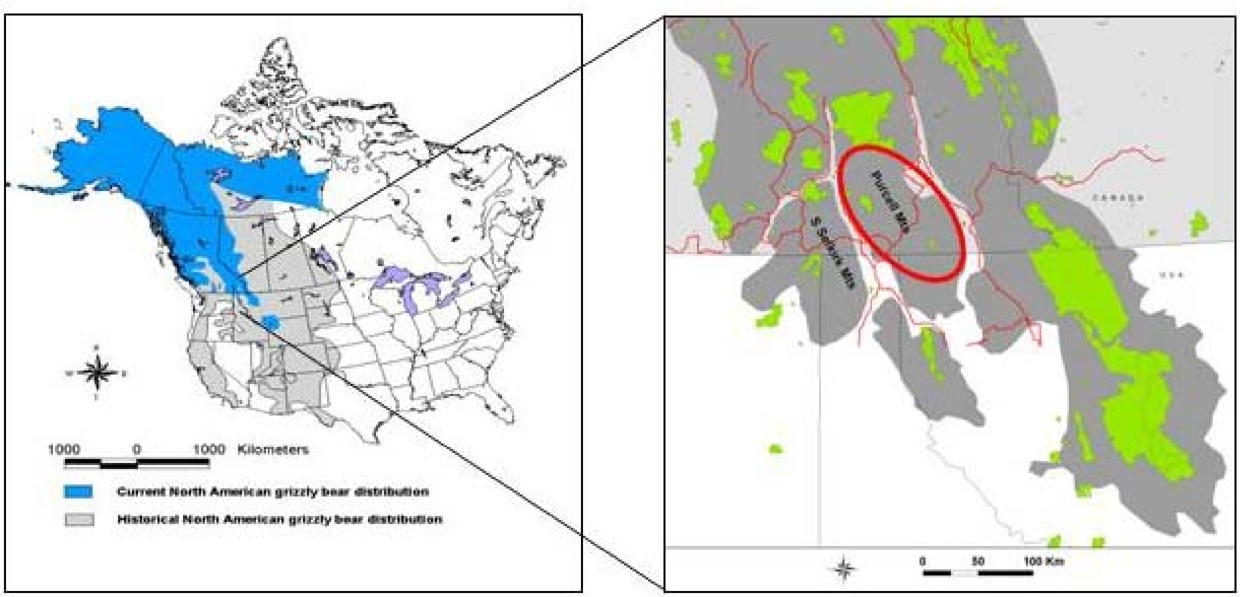
Another area of our research relates to specific bear management strategies aimed at improving habitat security for grizzly bears. We are in the process of identifying important and critical habitats (see above radio-telemetry comments), and understanding the spatially-explicit relationship of roads and human access to these important habitats. Many researchers have demonstrated that the number of roads and degree of human access are generally inversely related to grizzly bear habitat use (Archibald et al. 1987; Mattson et al. 1987; McLellan and Shackleton 1988; Kasworm and Manley 1990; Wakkinen and Kasworm 1997; Mace et al, 1996, 1999). A fundamental principle of grizzly bear management in threatened populations is to understand and manage this aspect of human-bear relations. Mace et al. (1996) found that bear avoidance and mortality risk increased as road densities increased. Nielsen et al. (2004a) found that while grizzly bears made use of cutting units and their associated roaded habitats in the foothills of Alberta, they likely experienced a higher mortality risk (Nielsen et al. 2004b). Boulanger (2005) used the same Alberta dataset as Nielsen et al. (2004a & b) and found that female grizzly bear survivability and productivity decreased as road densities increased. Nielsen et al. (2006) combined habitat selection data with mortality risk layers to predict source-sink dynamics. They concluded that the best approach for conservation management of grizzly bears would be to manage human access in areas of higher quality grizzly bear habitat.

It is the primary goal of the work presented in this report to provide map layers within a Geographic Information System (GIS) that identify spatially-specific areas of higher quality grizzly bear habitat for use in discussions of an Access Management Strategy (AMS) in the Yahk Grizzly Bear Population Unit (GBPU; Fig 2). We realize that the backcountry south Purcell road network is also a critical requirement of economic activity and recreation. Therefore, our efforts have been to determine the optimum areas where access management would enhance grizzly bear habitat security, and by extension, survivorship and productivity. RSF models have been used for predicting grizzly bear occurrence and habitat use in answering many types of ecological and management questions (Mace et al. 1996, 1999, Boyce and Waller 2003; Nielsen et al. 2002; 2004a; 2004b; 2006), including ones very similar to this effort. We therefore used GPS-telemetry data in RSF-modeling to correlate ecological, terrain, and human-use variables to bear habitat use to help in the development of an AMS for the Yahk area.

Our cumulative efforts in DNA surveys and trapping live bears in the past 4 years have led us to conclude that there may be a critically low number of female grizzly bears in the Yahk GBPU. Here we briefly review that evidence, primarily to develop a data-based motive for improving habitat security within the Yahk GBPU. First, Proctor et al. (2007) estimated that there were likely 24 grizzly bears south of Hwy 3 within Canada in the Purcell Mts. As approximately 25% of these should be adult females (McLellan 1989; Wakkinen and Kaswrom 2004), there may be 4-6 adult females in this unit. There have been 3 known adult female mortalities in the past few years further reducing this number. Further, one must also subtract projected unknown mortalities: There is an estimated 1:1 known mortality to unknown mortality ratio (McLellan et al. 1999) for grizzly bears in the region. However, we must consider that there is also some recruitment from sub-adults. Second, our 3 years of DNA surveys (2001, 2004, 2005; Proctor et al. 2007) sampled only 3 females south of Hwy 3 in contrast to 26 females north of Hwy 3 from the same sampling effort in each area. Third, our live trapping success of females is extremely low south of Hwy 3 in contrast to north of Hwy 3 (see Results). When one considers these data and our GPS-collar data (see Results) in light of the fact that Proctor et al. (2005a) found no female immigration into the Yahk GBPU, (Hwy 3 is acting as a filter to movement), the female-fragmented Yahk GBPU is of conservation concern and requires strategic management for population recovery to occur.

Figure 1a. Current and historic distribution of grizzly bears in North America; blue estimates current grizzly bear distribution. **b.** Close up of regional grizzly bear distribution; green represents protected areas, red lines are major highways, and our study area is within the red oval.

a. b.



Methods and Background

Radio telemetry

We have been radio-collaring grizzly bears in the study area since 2004. All capture work is in accordance with Canadian Council on Animal Care. Collars are designed to stay on animals for 2 seasons and are programmed to drop off in Fall of the 2nd season. Collars take GPS locations every hour; some data are uploaded from aircraft at intervals of approximately once per month and the rest of the data are collected when the collars fall off and we retrieve them.

The data we have collected so far provide a snapshot into habitat use of the collared bears. Because we take hourly locations (primarily for fine scale movement data), collars remain functional on bears for 1-2 seasons. Therefore our data do not represent lifetime home ranges, and only in a few cases do we have data from two full seasons. On the positive side, GPS collars provide many locations per animal throughout a season (1000-3000 locations), and this is a great improvement from VHF collars that typically provided 24-48 locations per season.

Roads and access

It has been well established that grizzly bears can survive and reproduce in roaded habitats (Mace et al. 1996). It has also been shown that mortality risk and avoidance of habitat within 500m of open roads increases with road densities (Mace et al. 1996). More specifically, successful females (females that survive long enough to, and actually do, reproduce) select home ranges that contain 56% *core habitat* (defined as habitat >500 m from an open road) on average in the northern US Rocky Mt. ecosystem (Mace et al. 1996) and 55% for the US portion of the Yaak ecosystem (Wakkinen and Kasworm 1997; note *Yahk* Canadian and *Yaak* US spelling). In fact, these metrics are used as the legal standard in the US Yaak: Habitat is managed to maintain 55% core habitat within each Bear Management Unit (BMU) accompanied by a road density target where 67% of the area has less than 1km road/km^2 (Wakkinen and Kasworm 1997). These standards have survived scrutiny by government agencies (USFWS, USFS), environmental organizations, and timber companies (C. Servheen, pers. comm.). Females are the focus because they have repeatedly been shown to be the most important cohort in grizzly bear population dynamics (Eberhardt et al. 1994; McLellan 1989; Garshelis et al. 2004). The key metric that underpins the logic of their access management is the amount of open (not managed for closures) road densities and *core* habitat that is within surviving and successfully reproducing female home ranges. The logic is that habitat characteristics selected by these “successful” females should be used to manage for a healthy population (and potential recovery if threatened). More direct support for the correlative associations between road densities and female grizzly bear success is provided by Boulanger (2005) who found that female survival and productivity decreased with increasing road densities within home ranges. This work provides a direct link to road density and population productivity, and underpins Alberta's new access management intentions (G. Stenhouse, pers. comm.).

We have GPS-telemetry data for 4 females and 8 males. None of the females and 4 of the 8 males spent time within the Yahk GBPU. These data patterns played a role in our decisions on how to proceed with our analysis of habitat and roads. We do not have the sample sizes to compare how grizzly bears in heavily roaded habitats fare relative to bears in less roaded habitats; we cannot directly explore what effect living in these different habitats might have on mortality risk or productivity (Nielsen et al. 2004a, b; Boulanger 2005). However, we explore our sample of grizzly bears and their relationship with road is several ways. First we examine road and habitat characteristics of successful female home ranges, and compare those with what is available. We also apply this comparison for each of the Bear Management Units (BMUs) we described in Proctor et al. (2007). BMUs are designed to approximate a female grizzly bear's home range, and theoretically contain 4 season's of appropriate habitat. Their main function is to partition habitat management across GBPUs so positive effects may be realized spatially. Second, we explore habitat selection and use of roads relative to their vehicle use levels in habitat modeling (see RSF modeling below) at a medium scale of multiple home ranges. And third, we look at the relationship between roads and females within their individual home ranges (See below). .

To understand home range selection, we compared "use" versus "availability" by comparing the proportion of *core* habitat within individual home ranges relative to that available. Core habitat was determined in a GIS environment by creating a 500m buffer around all roads and computing the percentage of area not contained within the buffered habitat within each BMU (*Available*). Road density was also determined by calculating a linear road density within each square kilometer and tabulating its average within each BMU. Then we computed values for these variables within female home ranges (*Use*). We used the most up-to-date road layer from Tembec Industries. The spatial extent of the Tembec road layer does not extend to all areas within our analysis area (GPS radio location areas, and the C Purcell GBPU extend beyond the Tembec road layer). Therefore, portions of our analysis were done using the provincial road layer, which in some cases (not all) has fewer roads. We indicate which road layer was used for which analysis. One implication of this is that analyses using the BC road layer may have been done with fewer roads than are actually on the ground. The Tembec road layer extended across the entire Yahk GBPU, but was limited on the western and northern edges of the S Purcell GBPU. Kernal home ranges were calculated using Hawth Tools within ArcMap 9.1 GIS. We also compared our set of successful females to a smaller set of unsuccessful females.

Habitat modeling

Our primary goal was to use our GPS data to predict areas of high grizzly bear occurrence. We aimed to cluster the higher quality grizzly bear habitat into polygons for consideration by stakeholders (timber industry, hunters, recreationists, and government) as optimal areas for access management. To predict high quality grizzly bear habitat, we developed RSF models (Boyce and McDonald 1999; Manly et al. 2002; Nielsen, et al. 2002) from 4 years of radio-telemetry data. We developed season- and sex-specific models where data was sufficient. RSF models involve spatially-explicit multiple logistic regression predictions applied in a GIS environment (Manley et al. 2002; Nielsen, et al. 2002). They associate grizzly bear habitat use, as determined through GPS radio-telemetry locations, with ecological, terrain, forest cover, and human-use variables (Table 1), and predict grizzly bear habitat use across the whole study area (Nielsen et al. 2002). Variable data was obtained from a variety of sources, including BC government TRIM (Terrain Resource Information Management), BTM (Baseline Thematic Mapping), and VRI (Vegetation Resource Inventory data) layers. The highway and human occurrence points (developments) layers were digitized from 1:50k topographic maps and ortho photos, greenness was derived from Landsat imagery using a TassleCap transformation (Crist and Ciccone 1984), and slope, solar radiation, and terrain ruggedness were derived from a digital elevation model. Data were modeled at the 100m x 100m pixel size.

Alpine, avalanche, burn and riparian habitats have been demonstrated to be important habitat types that attract grizzly bears because they contain a variety of food resources (Mace et al. 1996; McLellan and Hovey 1995; McLellan and Hovey 2001). Greenness, an index of leafy green productivity, likely correlates with a diverse set of bear food resources and is often found to be a good predictor of grizzly bear habitat use (Mace et al. 1996, Nielsen et al. 2002). Forest cover variables have been found to influence habitat selection (Apps et al. 2004). Ecological variables such as curvature index which identifies wet areas, terrain ruggedness which measures topographic complexity, and solar radiation, an index to vegetative productivity, all have the potential to influence habitat selection. Human-use variables have been repeatedly demonstrated to influence habitat selection (Mace et al

1996, 1999, Nielsen et al, 2002; Apps et al. 2004). Our roads variable was run several ways. First because the GPS points that we used for our both-sexes model went beyond the extent of the Tembec road layer, we used the BC provincial road layer for those analyses. The female GPS points were within the extent of the Tembec road layer so we used them in the female-only all season model. We also broke the Tembec road layer into Lower Use (very low and low vehicle use roads) and Higher Use (moderate, high and very high use roads) categories to explore selection or avoidance of roads of varying traffic volume by female bears.

Table 1. Variables used in Resource Selection Function (RSF) analysis of GPS radio-telemetry location data for grizzly bears in the South Purcell Mts.

	Variables		**Variables**
Land cover		**Ecological**	
	Alpine		Elevation
	Avalanche		Curvature Index
	Barren		Terrain ruggedness index
	Burn		Greenness
	Riparian		Slope
Forest cover			Solar radiation
	Forest age	**Human**	
	% crown closure		Human developments
	Old forest		Highway
	Young forest		Parks
	Recently logged		All Roads
	Cedar - Hemlock		Lower Use Roads
	Spruce - Sub alpine fir		Higher Use roads
	Douglas Fir		
	Lodgepole pine		
	White pine		
	Deciduous		

Due to sample size limitations, we restricted our both-sex analysis to 2 seasons: Pre-berry – den emergence until July 14 ("Spring"), and Berry – July 15 until den entrance ("Summer/Fall"). Due to limitations in early spring data we modeled female habitat use across the non-denning season. We also ran individual models within each home range for all successful females. Models were developed using 80% of the location data and the remaining 20% of the locations were used to validate each season's models (Hosmer and Lemshaw 1989; Boyce et al. 2002; Nielsen et al. 2002). RSF scores for each dataset (80% and 20%) were ranked, binned into 10 categories, and tested for their predictive abilities. We further tested for model predictability by scoring models for classification accuracy. Classification accuracy represents the proportion of correctly classified bear locations that have RSF scores higher than an optimized cut point. The cut point is the optimization of sensitivity and specificity curves (Hosmer and Lemshaw 1989) and loosely represents RSF scores above which the model predicts bear occurrence.

In each of our models we compared combined grizzly bear telemetry locations (*Use*) to an equal number of random locations (*Availability*) across a composite polygon that encompassed all GPS locations for each model's bears (S. Nielsen, pers. comm). The female All-seasons model has 4 females combined and run within one model. We also ran the females individually, and availability was derived from random points within each female's annual home range.

Model development followed protocols in Hosmer and Lemshaw (1989). First, all variables were tested for pairwise correlations and variables with a correlation index >0.7 were excluded from use within the same model. Second, all variables were run in a uni-variate logistic regression and ranked for their significance and explanatory power (R^2). Then models were built by adding variables in a step-wise fashion starting with the most influential variables (higher to lower R^2). Models were compared sequentially after each variable addition; variable significance, explanatory power (R^2), and likelihood were used to compare models and decide if a variable improved model predictability. Best models were the most parsimonious (fewest variables) providing the optimal predictability. Logistic regression modeling was done within the statistical software package STATA (Intercooled 9.2, College Station, Texas).

It should be noted that the variables we used are not necessarily primary functional factors that drive grizzly bear habitat use, but are likely correlates to those variables. Grizzly bears likely respond to seasonal food supplies, social requirements, security needs, and human influence, however, we do not have map products that depict all of these across regions. Therefore we used the multi-variate analyses with a variety of habitat and human-influence variables to model where bears are likely to occur. The input variables we used for modeling are very similar to other efforts of this type (Mace et al. 1996; Nielsen et al. 2002; Apps et al. 2004).

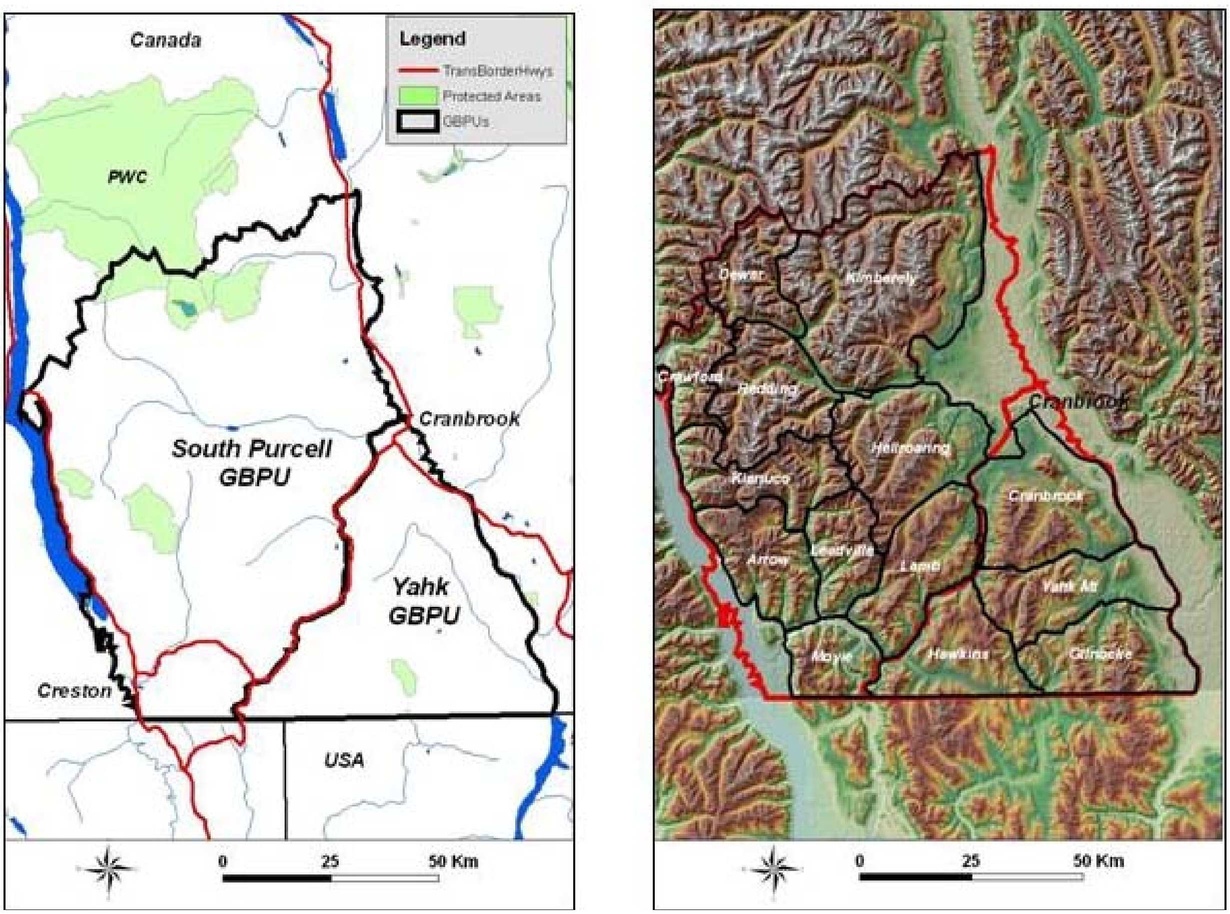
A main goal of our final models was to predict habitat use for potential access management. To do this, we planned to eliminate the influence of roads in our predictive model to better allow the identification of currently roaded habitats that might otherwise be good grizzly bear habitat. This was done differently for the female versus the both-sex models, as we explain in our Results (see below).

We combined the predictions of habitat quality for grizzly bears into a composite set of polygons where, from a grizzly bear perspective, it would be optimal to consider access management.

Linkage enhancement

We synthesized our previous 4 years of research and management effort to identify and enhance inter-population movement across BC Hwy 3 in the Purcell Mts. This effort culminated in a separate report (Proctor et al. 2008). The report reviews the need for linkage management, 3 years of DNA survey work, 4 years of GPS-telemetry work, results and identification of specific linkage zones, and culminates in recommendations on how to proceed to improve linkage across Hwy 3.

Figure 2. Grizzly Bear Population Units (GBPUs) and Bear Management Units in the South Purcell and Yahk GBPUs.



RESULTS

Radio telemetry

We have been radio-collaring grizzly bears in the study area since 2004 (total of 15 collared grizzly bears). We put out 4 GPS-collars on grizzly bears in the summer of 2007, of which 3 were females. To date, we have collected approximately 18,000 GPS locations from 12 collared grizzly bears (Fig. 3). Our trap night success for areas north of Hwy 3 is 1 grizzly bear for every 41 trap-nights. South of Hwy 3 we captured 1 grizzly bear every 95 trap-nights. For females specifically, trap success was 1 female per 74 trap night north of Hwy 3, in contrast with 1 female per 568 trap-nights south of Hwy 3.

Core habitat and road density

We developed 5 BMUs (Fig. 3; Proctor et al. 2006) that ranged in size from 300 to 800 km^2 south of Hwy 3 in the Yahk GBPU and 9 BMUs north of Hwy 3 in the S. Purcell GBPU (Table 2). In the Yahk GBPU, the percentage of each BMU that is *core habitat* for grizzly bears ranged between 10 – 29% (Table 2). The road densities range from 1.5 – 2.6 km / km^2 (Table 2). The estimated length of roads within each BMU ranges from approximately 500 km in the smaller Moyie unit up to ~2000 km in the larger 800 km^2 Cranbrook BMU (Table 2). North of Hwy 3 in the S. Purcell GBPU % core ranges from 34% to 78% and average road densities range from 0.35 to 1.40 km / km^2.

The majority (~67% or higher) of roads that are classified for intensity of use were low and very low use roads (Table 3) except in the Cranbrook and Hellroaring BMUs where they were 26% and 41 % respectively. The Cranbrook BMU has a high percentage of unclassified roads, so it's real situation on the ground may be significantly different than is apparent from the Tembec road layer.

On average, successful female grizzly bears appear to be selecting home ranges with more core habitat than is available. On average they selected habitat with 51% core within their 95% Kernal home ranges and road densities of 1.2 km / km^2 (Table 2). The 2 unsuccessful females had 25% and 19% core in their home ranges (Table 2). Looking at the available core habitat within local GBPUs, we found the average % core in the Yahk GBPU to be 16% and the average road density to be 2.3 km / km^2 suggesting that it is difficult for a female to find suitable secure habitat in that unit. The S. Purcell GBPU had an average % core of 53% and 0.97 km / km^2 road density (the S. Purcell average % core was calculated using the BC Provincial road layer because the Tembec layer does not provide complete coverage). Individually the two successful females north of Hwy 3 had 54% (Irish) and 43 % (Kelly, Fig. 4a) core (Table 2), while the BMU they resided in (Lamb) had 27 % available core, suggesting they selected home ranges within this BMU with less roads than were available on average. The third successful female selected a home range with 55% core within a BMU that averaged 47% core (Table 2). Two of the 3 successful females selected home ranges with higher percentages of low- and very low-use roads than were available on average in their BMU (Table 3). Irish's home range had 92% roads with low to very low vehicle use, and only 8% moderate to very high use roads, while her BMU contained 75% low to very low-use roads, and 23% higher traffic use volume roads. Kelly's home range contained 82% low to low-use, and 17% moderate to very high use roads in the same BMU (Table 3). Figures 5 and 6 illustrate 2 female home ranges in relation to roads. Figure 5 is a successful female (Irish) who resides just north of Hwy 3 in the S. Purcell GBPU that has selected an annual home range where ~54% is core habitat. In contrast, we provide the multi-annual home range (derived from VHF telemetry data collected by W. Kasworm) for the only female within the Yahk GBPU for which we have telemetry data. Her home range contains 19% core habitat (Fig. 6). Roads in Figs. 5 and 6 are categorized by intensity of use (see captions and legends).

Figure 3. GPS radio locations from grizzly bears over 4 years (2004 – 2007). Each color represents a separate grizzly bear.

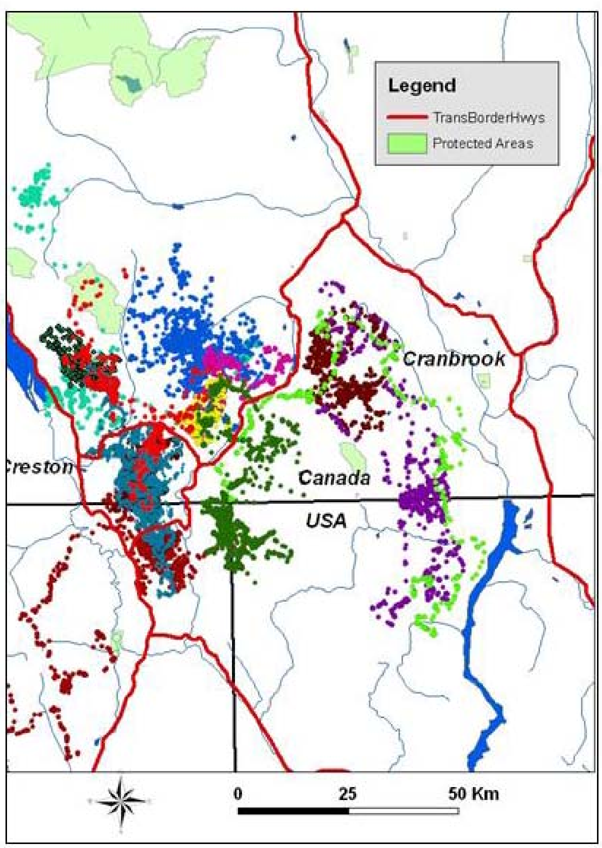


Table 2. "Core habitat" (area not within 500m of a motorized road) and road densities within grizzly bear management units, GBPUs, and Individual female grizzly bears in the south Purcell Mts.

	area km^2	% core	Avg. Road Density km / km^2	Km of roads
Female grizzly bears				
Successful				
Irish	107	0.54	1.22	131
Kelly	115	0.43	1.53	176
Maeve*	130	0.55	0.78	101
Average		**0.51**	**1.18**	
Not successful				
Marilyn	154	0.25	1.20	185
Terri 538	441	0.19	1.99	878
GBPUs				
S Purcell GBPU*	6894	0.53	0.97	6687
Yahk GBPU	2721	0.16	2.25	6122
Yahk GB (habitat polygons)	950	0.24	1.78	1691
BMUs S of Hwy 3				
Moyie	320	0.10	1.55	496
Hawkins	563	0.21	1.83	1030
Gilnocke	622	0.22	1.72	1071
Yahk Mt	584	0.29	2.52	1472
Cranbrook	804	0.13	2.63	2115
BMUs N of Hwy 3				
Arrow*	104	0.47	0.92	96
Lamb	110	0.27	1.71	188
Kianuco*	139	0.75	0.40	56
Leadville	82	0.47	1.10	90
Hellroaring	133	0.25	1.90	253
Crawford*	121	0.49	0.97	117
Redding*	122	0.76	0.35	43
Dewar*	101	0.78	0.41	41
Kimberely*	196	0.73	0.43	84

***** values calculated using BC provincial road layer due to spatial extent of Tembec road layer

Table 3. Use of roads by Bear Management Unit and successful females in the Yahk and S Purcell GBPUs. Roads were categorized from Tembec road use estimates.

	% Road use							
	non coded	**very high**	**high**	**moderate**	**low**	**very low**	**total**	**% low and very low relative to coded roads**
Yahk GBPU	25.4	4.6	3.9	7.7	9.8	22.3	73.7	66
Yahk BMUs								
Moyie	6.1	4.4	12.6	13.8	8.4	46.5	91.7	64
Hawkins	12.3	4.4	7.0	8.1	12.5	41.1	85.4	73
Gilnocke	1.2	9.7	8.6	12.1	16.7	49.3	97.7	68
Yahk Mt	2.2	10.9	4.4	8.8	22.4	48.5	97.3	75
Cranbrook	43.3	1.3	1.8	7.2	3.2	0.6	57.4	26
S Purcell BMUs								
Arrow	29.1	1.8	4.3	6.6	8.5	20.2	70.6	69
Lamb	2.0	4.4	8.6	10.2	46.0	25.3	96.5	75
Kianuco*	40.2	2.4	2.2	0.0	0.0	13.0	57.8	74
Leadville	6.8	7.8	15.5	4.4	13.3	41.7	89.6	67
Hellroaring	10.3	8.0	9.8	28.8	26.8	6.1	89.7	41
Crawford**								
Redding*	11.3	17.9	3.9	1.5	20.9	31.9	87.4	69
Dewar*	0.0	12.5	11.5	6.2	8.8	61.0	100.0	70
Kimberely*	13.2	6.4	0.0	2.4	21.1	45.3	88.4	88
Average	13.7	7.1	6.9	8.5	16.0	33.1	85.3	69
Successful females								
Irish	0	0	8.4	0	27.0	64.6	100.0	92
Kelly	0.8	6.4	6.2	4.1	49.8	32.3	99.8	83
Maeve*	27.8	0	5.0	8.1	15.8	15.5	72.2	70

* incomplete coverage
** no coverage

Figure 4. Successful female grizzly bear's (Kelly) annual home range (HR) with road layer (classified roads, 500m buffers). Yellow areas are 500m buffered roads. Light Blue lines are low to very low use roads. .This bear resided north of Hwy 3 in the Lamb BMU within the S Purcell GBPU. She avoided roads at 2 scales: a) First, at the home range selection scale where she selected a HR (red polygon) with 43% core from 34% available within the Lamb BMU. b) Second, she avoided roads within her HR (RSF model, Table 5) as indicated by her green location points.

a. b.

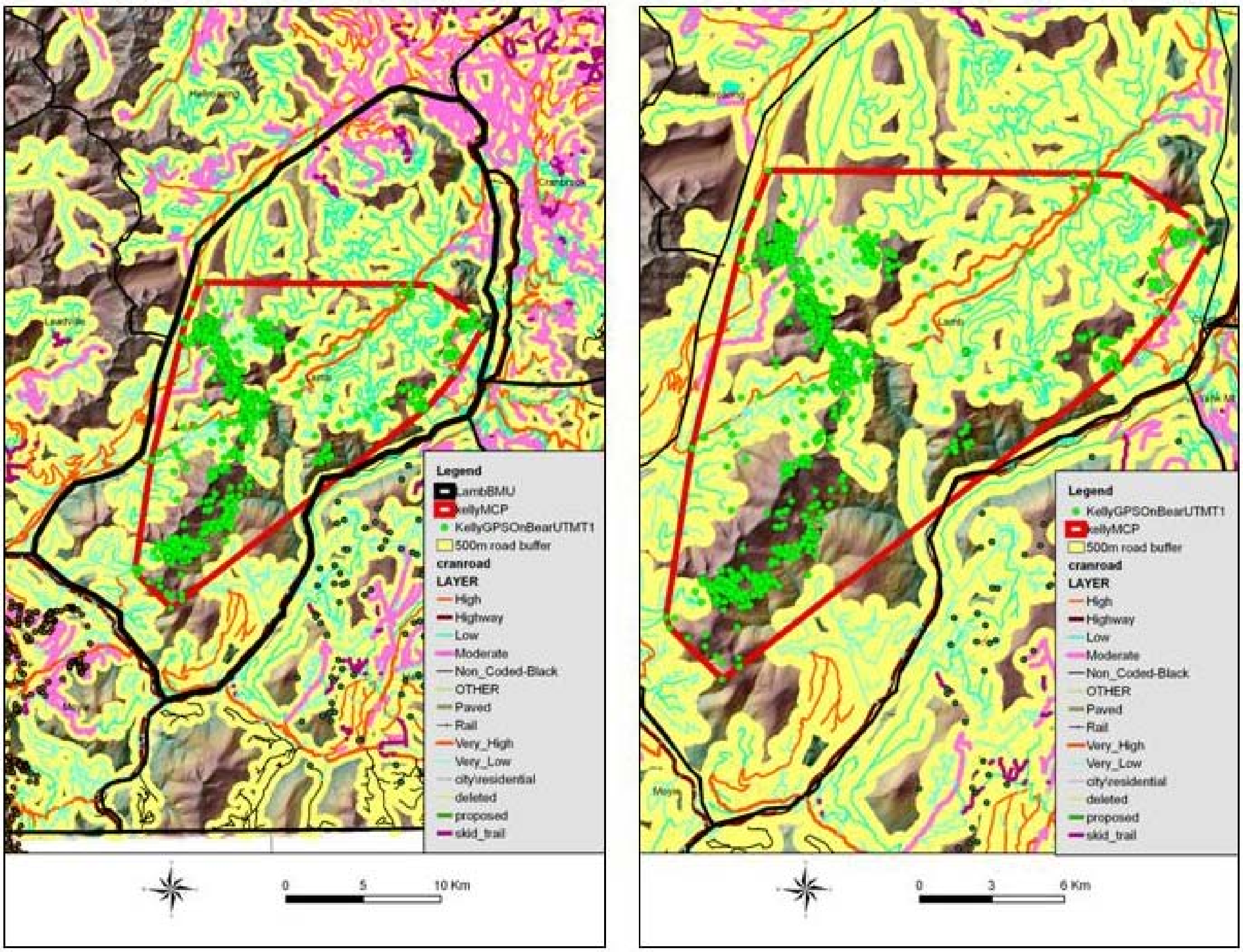


Figure 5. Successful female (Irish) grizzly bear 2004 home range with road layer. This bear resided just north of Hwy 3 and the town of Yahk, BC and had 54% core (habitat > 500m from a road) within her 2004 home range. White roads are low (or very low) use.

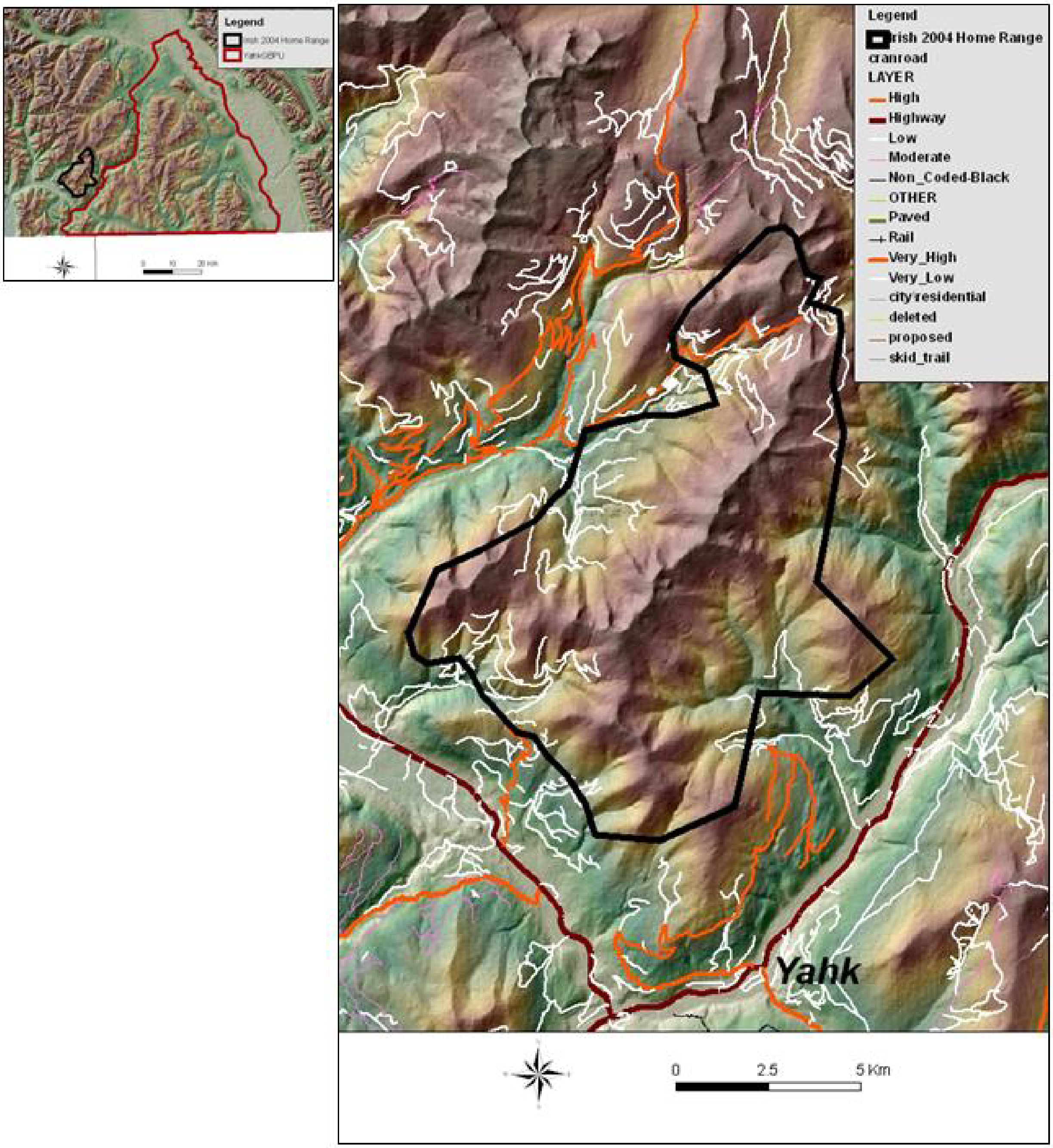
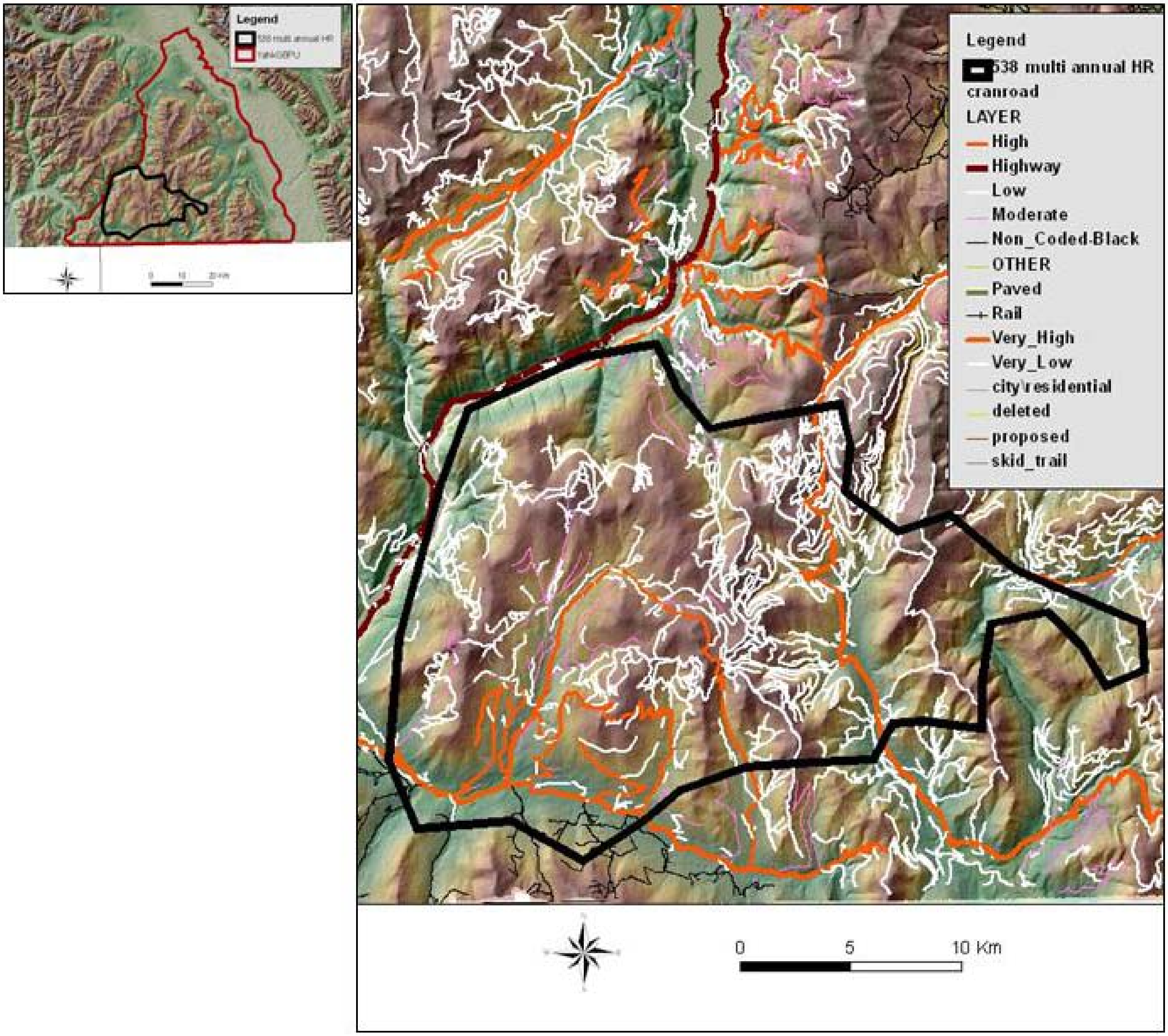


Figure 6. Unsuccessful female grizzly bear (Bear538) multi-annual home range (VHF data; W. Kasworm, unpubl. data) with road layer. This bear resided south of Hwy 3 in the Yahk GBPU and had 19% core (habitat > 500m from a road) within her home range. Her location data was collected via VHF, not GPS, and were thus not used in the habitat modeling. White roads are low (and very low) use.



Resource selection function modeling

Sample sizes permitted a both-sex model for both Spring and Summer/Fall seasons. The female-only model encompassed all seasons because of limited spring data for females and low sample sizes (Fig. 7a). We report both-sex models for Spring (Table 4, Fig. 7b) and Summer/Fall (Table 4, Fig. 7c). Because of their importance to population productivity and therefore management, females were included in all models; male-only seasonal models were considered less useful for management purposes than models with both sexes. Our models do an admirable job of predicting where we found bears to occur. In the model validation process, training models (built from 80% of locations) were highly predictive of the remaining 20% of locations (Fig. 8). The female all season model was significant (Table 4, $R^2 = 0.21$, $p < 0.001$) as were the both-sex spring ($R^2 = 0.10$, $p < 0.001$), and both-sex Summer/Fall ($R^2 = 0.17$, $p < 0.001$) models. The classification accuracy of the models were moderate at 63% for the female all season model and 64% for both both-sex models. To visualize the predictability of our female-only model, we present an example of the model predictions with actual locations from 2 overlapping females (Fig. 9).

We also present the results of individual modeling of successful females (Table 5). One of the 3 females avoided roads, while the other 2 were neutral to roads. The females that were neutral to roads, selected home ranges containing markedly more core habitat than was available in the BMUs. However, all three females selected home ranges with more core than was available in their BMUs (see results above). It is important to remember that omission of a variable from the best (most parsimonious and predictive) RSF models doesn't mean the variable was not selected for or avoided by bears, but that other variables were better predictors of grizzly bear occurrence. We have therefore provided the uni-variate results in addition to results of the most parsimonious multi-variate predictive models (Table 4 & 5), allowing for consideration of all landscape factors to which bears appear to be responding. Greenness (a measure of productivity in the form of an annual green leafy index) and Elevation were consistently the best predictors of bear occurrence. Terrain ruggedness, alpine habitats, Englemann spruce - subalpine fir (ESSF) forests, and solar radiation were selected for and were also important predictors across sexes and seasons. Highways, human developments, and riparian habitats were consistently avoided. All roads were selected for in the both-sex Spring model, neutral in the both-sex Summer/Fall model, and avoided by females in the all-season model. Both categories of roads (Lower and Higher Use) were avoided by females in the all-season model. There were two best models that differed by the inclusion of either the Lower Use roads or the Higher Use roads variables. One of our goals was to identify higher quality habitats without the influence of road avoidance; we therefore present our best models without the roads variables when we are selecting habitat to optimize access management decisions (Figs. 7a, b, c & 10).

We found differences in habitat use according to season and sex, however differences were not marked. Considering our goal was to identify higher quality habitat where access management would improve habitat security, the differences were subtle enough to justify providing a composite model for all sexes and all seasons (Fig. 10). Habitat with RSF scores ≥0.6 were integrated into a set of polygons that are offered as the best available habitat for consideration of access management that would positively effect grizzly bears security within BMUs in the Yahk GBPU. These polygons are what we consider to be the best data-based and objectively-derived higher quality grizzly bear habitat; presentation of these polygons provides a starting point for negotiation of access management by the diverse stakeholder groups.

The output from this effort has been shared with all appropriate stakeholders in the larger access management discussion, including maps, GIS shape-files, and a powerpoint presentation describing background, methods and results of this effort. The "homework" for each group is to use these products to guide their input into what roads might be managed for the benefit of grizzly bears, with the least cost for each organization.

Table 4. Results from uni-variate and multi-variate logistic regression analyses depicting variables that were selected for or avoided by male and female grizzly bears in Resource Selection Function modeling within the S. Purcell and Yahk Grizzly Bear Population Units. Variables with only one symbol, were selected (+) or avoided (-) according to uni-variate analyses. Variables with a double symbol were selected (+ +) or avoided (- -) within the final predictive models.

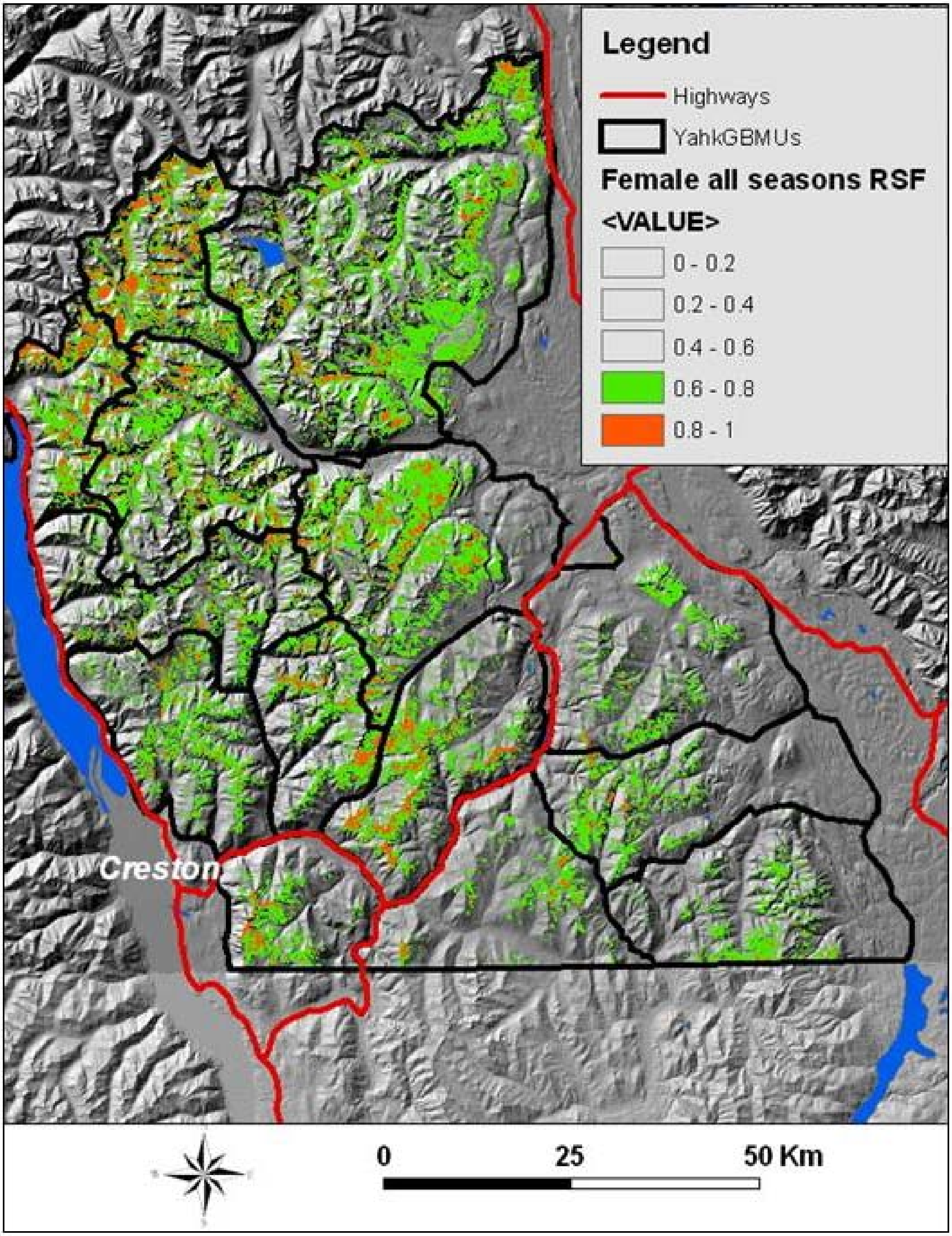
Variables	**Females**	**Both Sexes**	
	All season	**Spring**	**Summer-fall**
greenness	+ +	+ +	+ +
extreme greenness	-	-	-
elevation	+ +	+ +	+ +
extreme elevation	-	-	-
terrain ruggedness	+	+	- -
extreme ruggedness	-	-	-
alpine	+ +	+	+ +
highway	-	-	-
human development	-	- -	- -
spruce-fir (essf)	+	+ +	+
solar radiation	+	+	+
all roads	-	+ +	+
low use roads*	- -		
high use roads*	- -		
riparian	-	-	-
Douglas fir orest	+	+	+ +
old forest*	-		
road - old forest		- -	

Table 5. Results from uni-variate and multi-variate logistic regression analyses depicting variables that were selected for or avoided by indivudal female grizzly bears in Resource Selection Function modeling within the S. Purcell and Yahk Grizzly Bear Population Units. Variables with only one symbol, were selected (+) or avoided (-) according to uni-variate analyses. Variables with a double symbol were selected (+ +) or avoided (- -) within the final predictive models.

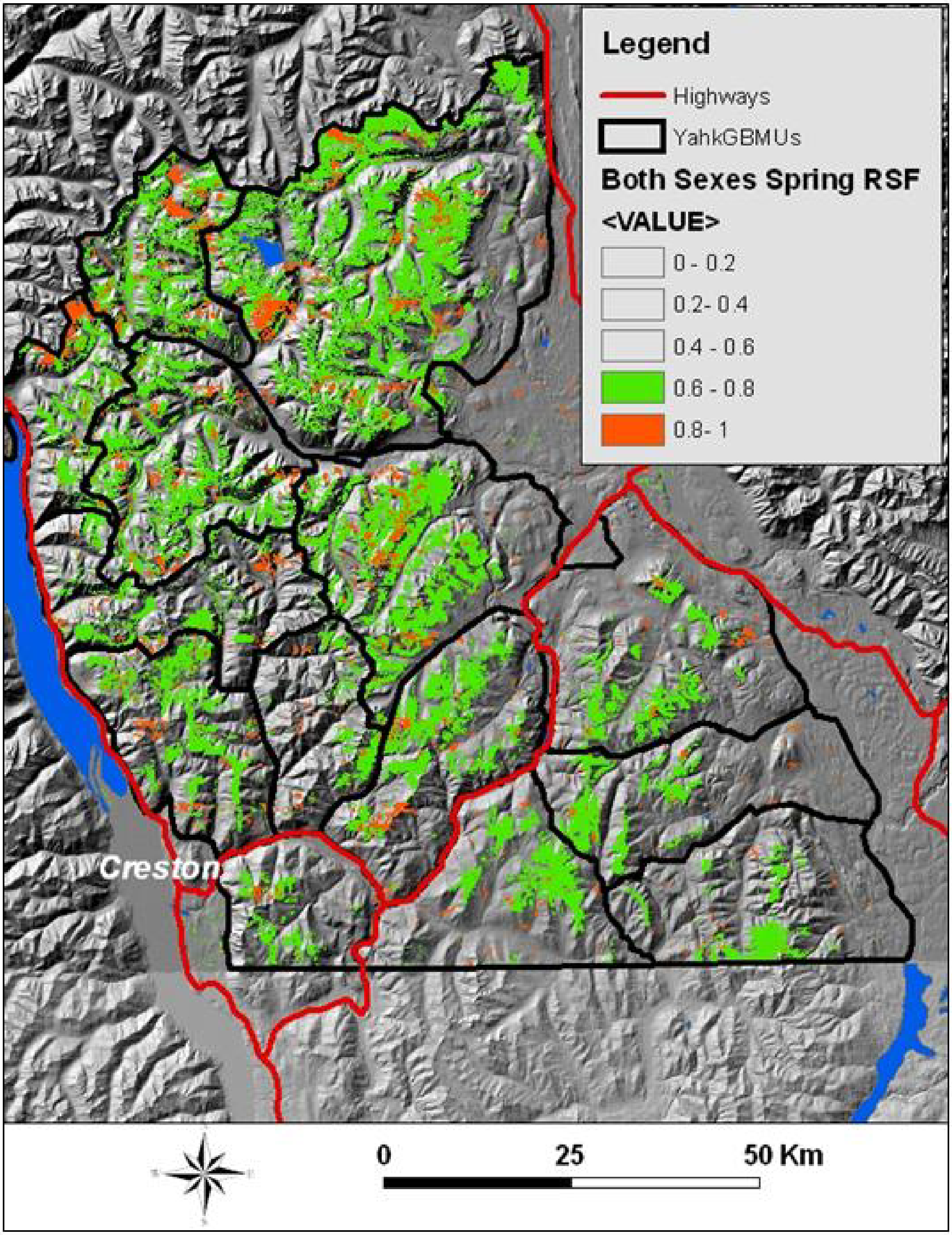
	Female		
Variable	**Irish**	**Kelly**	**Maeve**
greenness	+ +	neutral	+
elevation	+ +	+ +	+ +
alpine	+	+ +	
solar	+ +	+ +	+
old forest	+ +	- -	- -
Douglas fir	+ +	neutral	-
roads	neutral	- -	neutral
road-old forest	-	-	- -
cedar-hemlock	-	- -	-
young forest	-	+ +	+
recent log	+	- -	-
solar	+	+	+
canopy closure	-	neutral	-
deciduous	-	-	-
spruce-fir (essf)	neutral	+	+
lodgepole pine	neutral	+	+
barren	neutral	-	+
white pine	neutral	-	neutral

Figure 7. Grizzly bear Resource Selection Function models for **a.** females all seasons, **b.** both sexes Spring and, **c.** both sexes Summer/Fall, by Bear Management Units within the Yahk and S. Purcell GBPUs.

7a. Female only all season RSF



7b. Both-sexes Spring RSF



7c. Both sexes Summer/Fall RSF

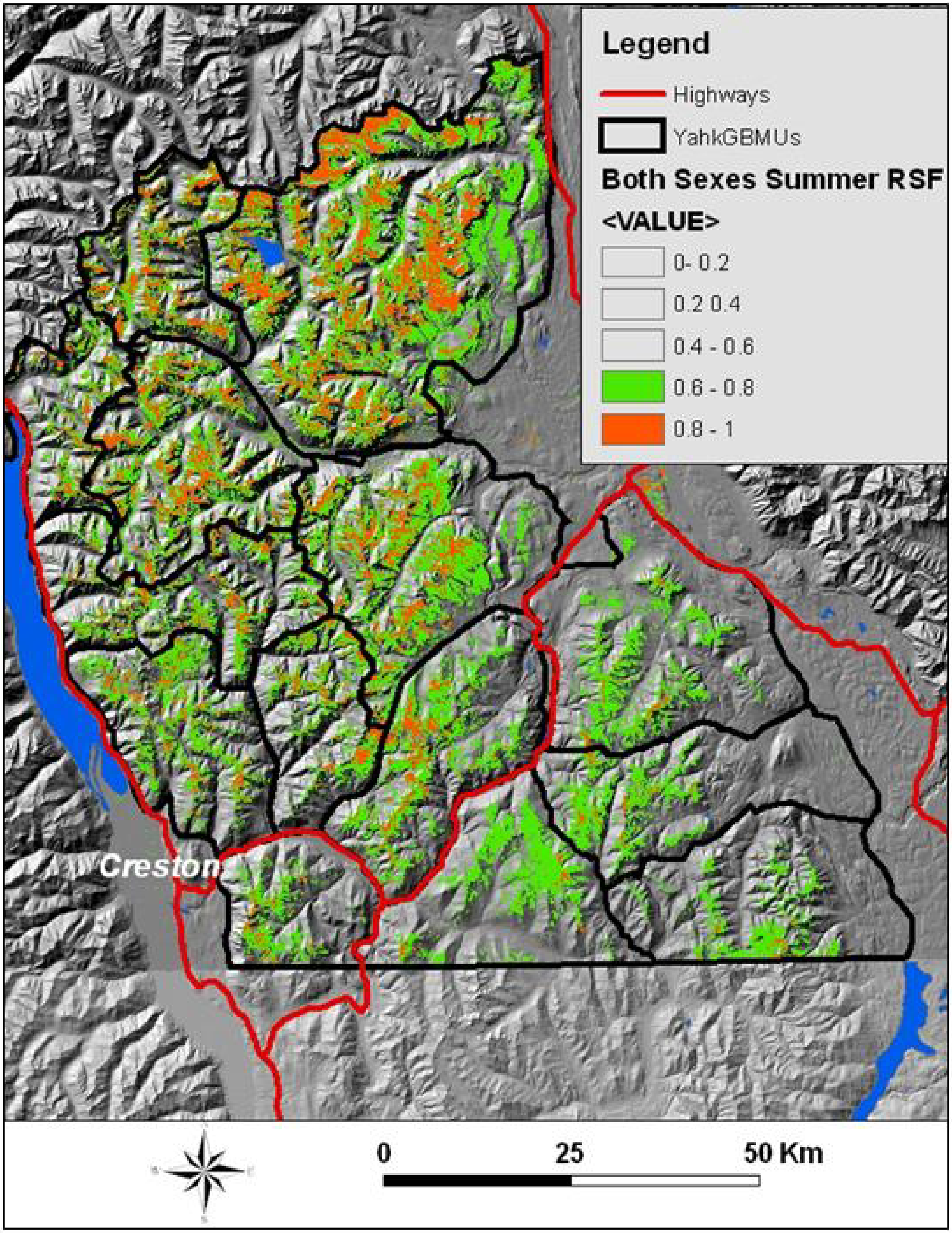
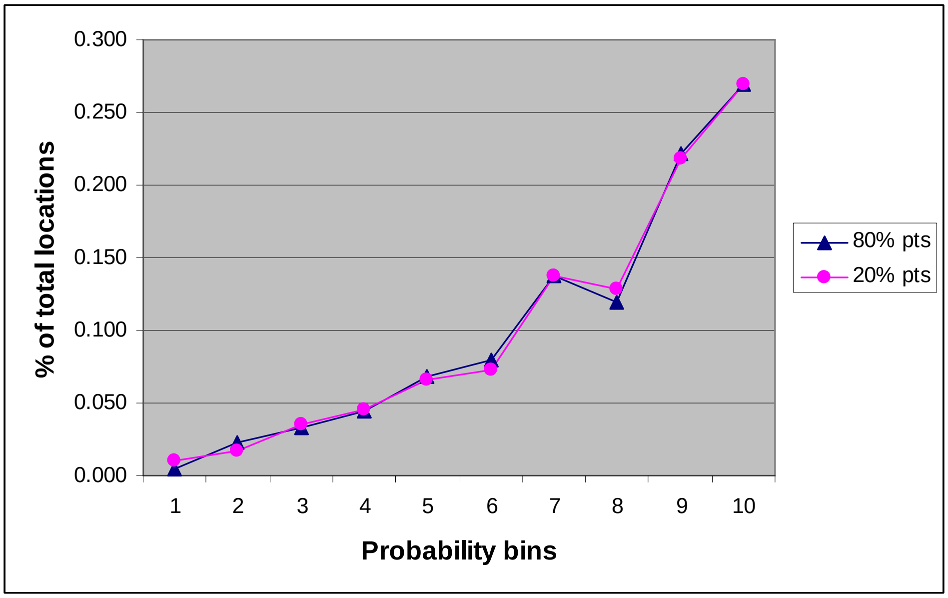


Figure 8. Validation of a both-sex Summer/Fall RSF model. This shows the close relationship of the distribution of RSF scores between the training (80% of location points) and validation (20%) models.



Linkage

We have completed a Linkage Management Plan for the Hwy 3 area within the Purcell Mts (Proctor et al. 2008). It is a separate stand-alone document that details the background, objectives, methods, results and recommendations for enhanced linkage management along Hwy 3. Briefly, it presents results from previous years' work culminating in a DNA-survey probability of occurrence model and a GPS-telemetry model designed to identify areas where grizzly bear habitat exists to link areas north and south across BC Hwy 3. It compares these predictions to actual bear crossings documented with telemetry. All information is integrated to identify specific "Linkage Zones" and the report makes management recommendations designed to help facilitate the secure movement of bears through these areas for government, industry, private land owners, and the public. Identified Linkage Zones can be viewed as the blue polygons in Figure 10.

Figure 9. An example of the female Resource Selection Function model in relation to GPS locations for 2 successful females (Irish and Kelly). Female GPS locations are in blue and brown points overlaid on the higher quality (≥0.6 RSF score) predicted female grizzly bear habitat (green and orange shaded area).

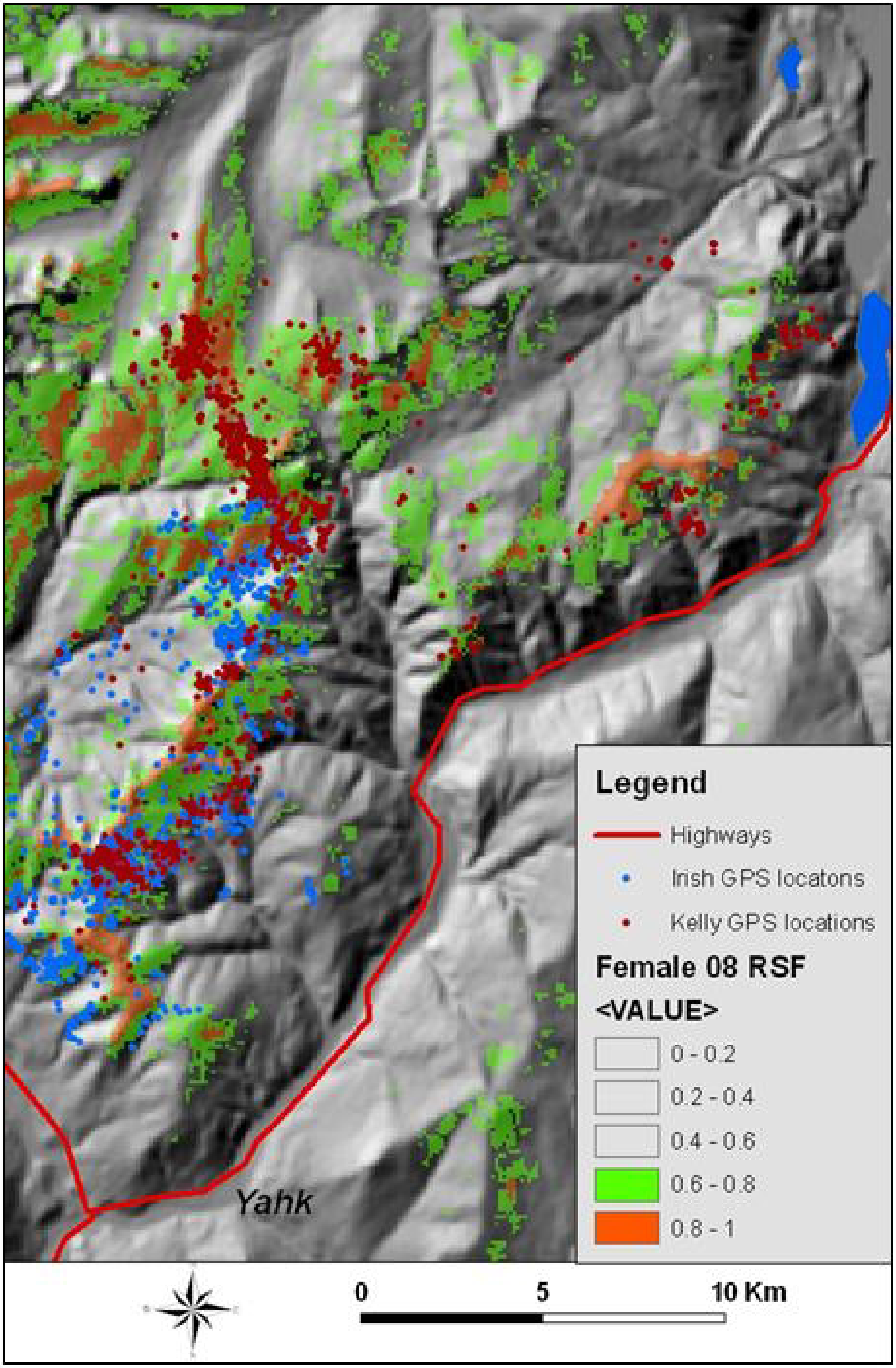
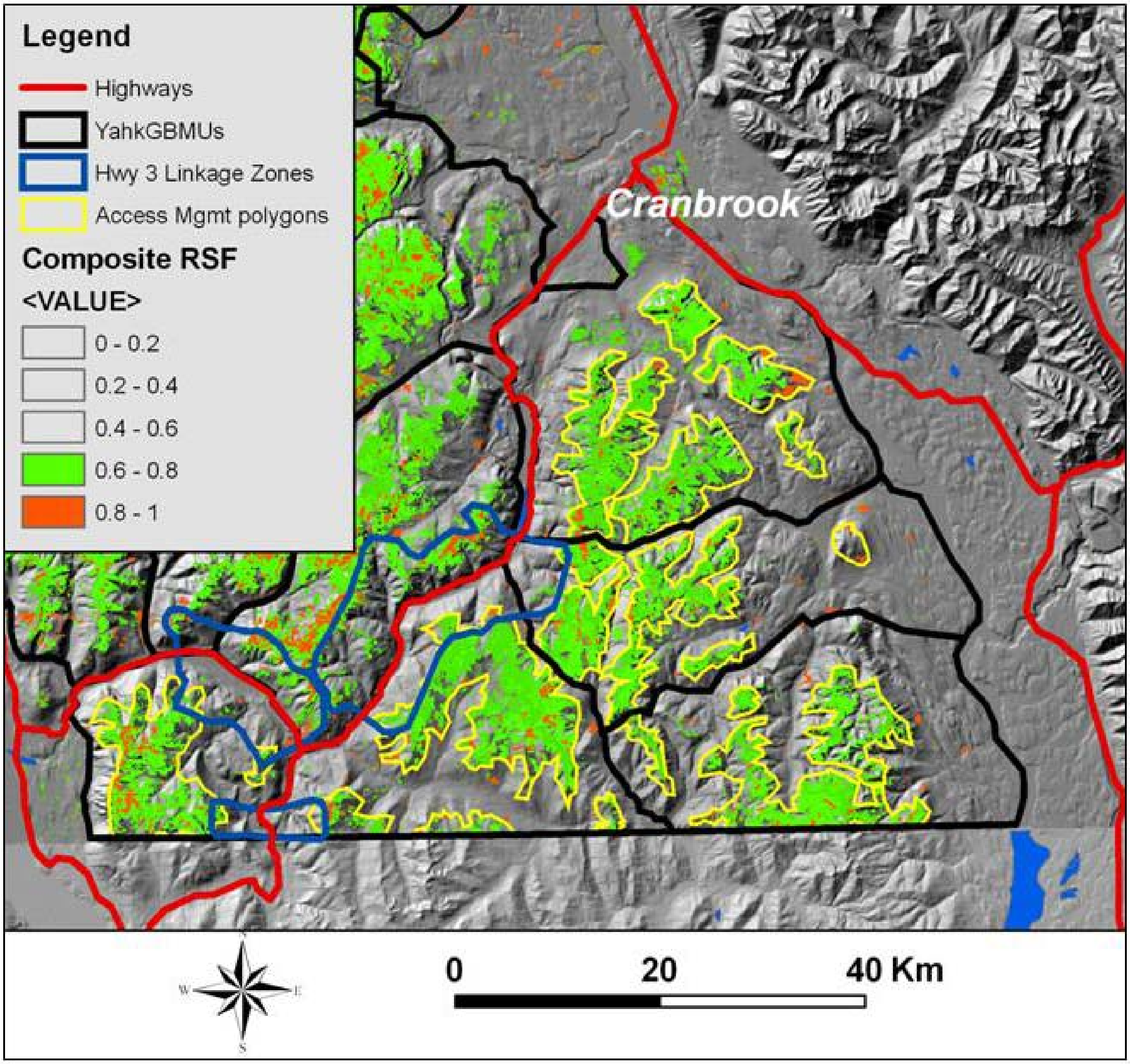


Figure 10. Polygons of higher quality grizzly bear habitat where access management might be considered to optimize positive effects for grizzly bears within Bear Management Units of the Yahk GBPU.



DISCUSSION

This report is an annual update of the progress we have made in year 4 of a 10 year project.

The population of grizzly bears living south of BC Highway 3 in the Purcell Mountains contain approximately 40-50 animals (25 in Canada - Proctor et al. 2007; 15-25 in the US - Kasworm et al. 2006). This population is declining (~3% / yr, Wakkinen and Kasworm 2004), fragmented (Proctor et al. 2005a), and legally threatened (Hamilton et al. 2004). Provincial estimates suggest that the Yahk GBPU is at 44% of its capability (potential, Table 6). The threshold for threatened status in BC is a population that is below 50% of capability, as the Yahk GBPU. That comparison is using the Province's extrapolated density of 23 GB / 1000km^2. Recent estimates by Proctor et al. (2007) derived from recent population surveys suggest the density in the Yahk GBPU is 7.5 bears / 1000km^2 resulting in that GBPU being at 20% of capability. Even if capability is estimated high for this GBPU, the population is below par. Our very low female capture rate in DNA surveys and live capturing for radio collar work is consistent with the prognosis of a depressed grizzly bear population in the Yahk GBPU.

Table 6. Density estimates for grizzly bears in the Yahk GBPU, with estimated grizzly bear numbers in parentheses. *Capability* is defined in Hamilton et al. (2004) as the inherent number of bears the area could hold without human influence. *Effectiveness* is defined within Hamilton and Austin (2004) as capability adjusted for human influence. These values and the *2004 estimate* of the Yahk grizzly bear population were BC Provincial extrapolated estimates from Hamilton et al. (2004). Proctor et al.'s (2007) more current estimate is derived from recent population surveys done in the region.

	Density, GB / 1000 km^2			
GBPU	**Capability**	**Effectiveness**	**2004 estimate**	**Proctor et al. 2007**
Yahk	37 (101)	29 (73)	23 (44)	7.5 (20)

The Yahk GBPU clearly needs enhanced management activities to be returned to a self-sustaining healthy population. We envision self-sustaining status to mean that the Yahk GBPU have sustainable mortality rates over the long-term, accompanied by functional linkage across Hwy 3 to the

C. Purcell GBPU. By functional linkage we mean the occasional successful (results in breeding) female that migrates from the S. Purcell GBPU (or the Rockies). The Yahk GBPU is likely too small to self-sustain on its own over the long-term, if it were completely isolated form neighbouring units.

Core habitat and road density

We found that the successful females, those that survived and reproduced, selected on average 51% of their home range to contain no roads and this is consistent with other researchers (Mace et al. 1996 – 56%; Wakkinen and Kasworm 1997 – 55%). Our average is likely biased low for the total study area (the Yahk and South Purcell GBPUs) because we targeted bears in the heavily roaded portion near Hwy 3. At the scale of the BMU, both successful females living in the Lamb BMU (Irish and Kelly, Fig. 2) avoided roads by selecting home ranges with more core than was available within their BMU (Irish 54%, Kelly 43 %, Lamb BMU 27% Table 2). The other successful female (Maeve) also selected more core than was available within her BMU (Maeve 55 %, Arrow BMU 47 %). Noteworthy is the fact that the average % core for the Yahk GBPU is 16%, suggesting that it may be difficult for females to find suitable habitat. This may be one of the reasons that after 4 years of effort in the Yahk GBPU, we have captured or DNA-sampled very few female grizzly bears. This is in contrast to our success in capturing and sampling females just to the north of Hwy 3 in the S. Purcell GBPU. There is much more potential core habitat in the S. Purcell GBPU to the north of Hwy 3 where 7 of 9 BMUs have ~50% or greater (Table 2).

Successful female grizzly bears in the US have been found to have road densities averaging 0.6 km / km^2 in their home ranges (Mace et al. 1996; Wakkinen and Kasworm 1997). The average for our successful females was 1.2 km / km^2, and again this is likely biased high due to our collaring bears in heavily roaded portions of the study area. The road layer we used is coded for intensity of use, and the majority of roads in the female home ranges. Lower Use roads (Table 3, Figs. 4, 5, & 6). It is possible that some of the very low use roads in the road layer have overgrown and become impassable. However, use of these road networks is becoming popular among some of the public using all-terrain recreational vehicles, so removal of these roads from analysis would require field inspection of actual road conditions.

One challenge in this analysis was trying to decide if low and very low use roads impact grizzly bears. We were interested not only in female habitat use, but more importantly, the habitat selected by *successful* females (surviving and productive). Low female sample sizes in our data did not allow us to compare survival rates and reproductive output in relation to road densities. However, while our successful female bears did select home ranges for higher core than was available within their BMUs, in doing so they selected home ranges with a higher percentage of low to very low use roads than were available in their BMUs. This suggests two explanations: First, successful female selection of home ranges was consistent with trying to minimize their interaction with humans -- selection for higher % un-roaded core); and second, they selected home ranges with the least human use – low to very low road densities. Mace et al. (1999) also found female grizzly bears avoided roads in all use classes. They divided road use into 3 categories: low = < 1 vehicle/day, moderate, between 1-10 vehicles/day, and high > 10 vehicles/day. All 3 categories of roads were significantly and negatively associated with avoidance by female bears. Nielsen et al. (2004a & b) found that use of cutting units and their associated road densities resulted in a higher mortality risk; Using the same dataset as Nielsen et al. (2004a & b), Boulanger (2005) and found that female grizzly bear survival and reproductive output decreased as road densities increased. Nielsen et al. (2006) predicted source and sink habitat by linking habitat quality with mortality risk and managing access in higher quality habitat optimized the conservation management of grizzly bear and human uses across the landscape. That is the goal of this effort and the following section discusses the results of that effort.

Resource selection function modeling

Variation in habitat selection between individual bears has been shown (Nielsen et al. 2002; Mace et al. 1996) and is expected. While previous studies have demonstrated that males and females do select habitat differently (Mace et al. 1996; Wakkinen and Kasworm 1997), our sample sizes at this time are too small to allow individual-based sex-specific habitat selection models; we have data from only 4 females, and this would not be sufficient to completely characterize female grizzly bear habitat use in all appropriate seasons. Our main goal is to use RSF models to predict where the higher quality grizzly bear habitat occurs for the purpose of optimizing an access management strategy. Because we had a modicum of female GPS location data to date, and because it is *female* habitat security with which we are most concerned, we have created both-sex models to supplement our female only models.

Other researchers have found seasonal habitat shifts from the pre-berry season to berry season around mid July (McLellan and Hovey 1995; Mace et al. 1996). While we found seasonal differences in habitat selection, they were subtle. The main differences we found between seasons were the shift from habitats closer to roads in the Spring to the selection of more alpine habitats in the Summer/Fall. These findings are consistent with other researchers, particularly the attraction to roaded habitats in spring (Mace et al. 1996, 1999). One reason the seasonal differences tended to be more subtle in our study area is that food resources in the Yahk GBPU do not appear to be clustered as predictably as in some other habitats within the Kootenay region. While bears were attracted to alpine habitats, these habitats are not extensive in the Yahk GBPU. Alpine habitat in the Yahk consists of scattered but relatively low mountain tops (~ 5000-7000 ft.) and ridges, in an otherwise forested landscape. Some summer /fall berry patches exist (Upper Arrow Crk., Grizzly Basin in upper Hazel Crk.), but these habitats are not exclusive to summer, owing to rich spring food resources also being available in these areas. These patterns are evident in the telemetry data and are the consensus of our entire field research team. Additionally, avalanche chutes, that have been repeatedly shown to be important clustered spring habitat (McLellan and Hovey 1995; Mace et al. 1996, 1999, Apps et al. 2004), are generally missing from the Yahk GBPU.

We found greenness to be one of the best predictors of bear occurrence and this result is supported by other studies (Mace et al. 1999; Nielsen et al. 2002; Boyce and Waller 2003). Greenness can be an unsatisfying variable because it represents a suite of habitat types that display high annual leafy-green productivity (White et al. 1997). High greenness values appear to be a reasonably good predictor of grizzly bear food resources. Habitats associated with high levels of greenness include alpine areas, regenerating cut blocks, riparian areas, and avalanche chutes.

We found that human development and highways were avoided and this is consistent with results from other work (Mace et al. 1996; 1999). We found selection for roads in Spring in the both-sex model, and avoidance in the female-only all-season model; this is also consistent with other studies (Mace et al. 1996), as spring habitat is often associated with lower elevation habitats near roads. Females avoided all categories of road use in our all season female model. We also found avoidance of riparian habitats. At first blush, this is counter-intuitive because bears are known to be attracted to riparian habitat when it is not closely associated with roads (McLellan and Hovey 1995). In our case, riparian habitat is almost always associated with roads and valley bottoms.

We found that one successful female (Kelly) avoided roads at 2 scales: First at the scale of home range selection, she selected a home range with 43% core from within a BMU that offered 27% core (Table 2); she also avoided roads within her home range (Table 5) as demonstrated in her individual home range model (Fig 4). Irish also avoided roads at the home range scale by selecting a home range with 55% core from a BMU that offered 27% core. Within her home range, however, she did not avoid roads (Table 5), having already selected a home range with substantially reduced levels of moderate, high and very high use roads. Maeve, the third successful female, had a similar pattern In the all season female model, bears avoided both the Lower and Higher Use road categories.

One of our goals was to identify higher quality grizzly bear habitat with RSF models that did not reflect avoidance of roads. . We therefore ran a separate RSF analysis without roads as a variable for the female model where Lower and Higher Use roads were avoided in our best model. We retained the positive road variable in our both-sex Spring model, because of the association of roads with low elevation riparian habitats, and likely reflecting habitat selection for food resources that occurred near roads, particularly early in the season when snow precludes habitat use in higher country. Our best summer model for both sexes did not have roads as a variable, so this model was used directly in developing our optimized access management polygons.

As mentioned above, due to low samples sizes and the fact that we found only subtle differences between our seasonal models, we elected to create a composite all-sex all-season predictive model for discussions of access management between stakeholders. Realizing that access management can be a challenging and controversial effort, the wider range of higher quality habitat identified in the composite model provides many options for access management, and is more likely to enhance grizzly habitat for females than a male-based model would. Experience from the Yaak ecosystem in the U.S. suggests that flexibility for stakeholders in selecting what roads might be managed is very useful to the process (W. Kasworm pers. comm.).

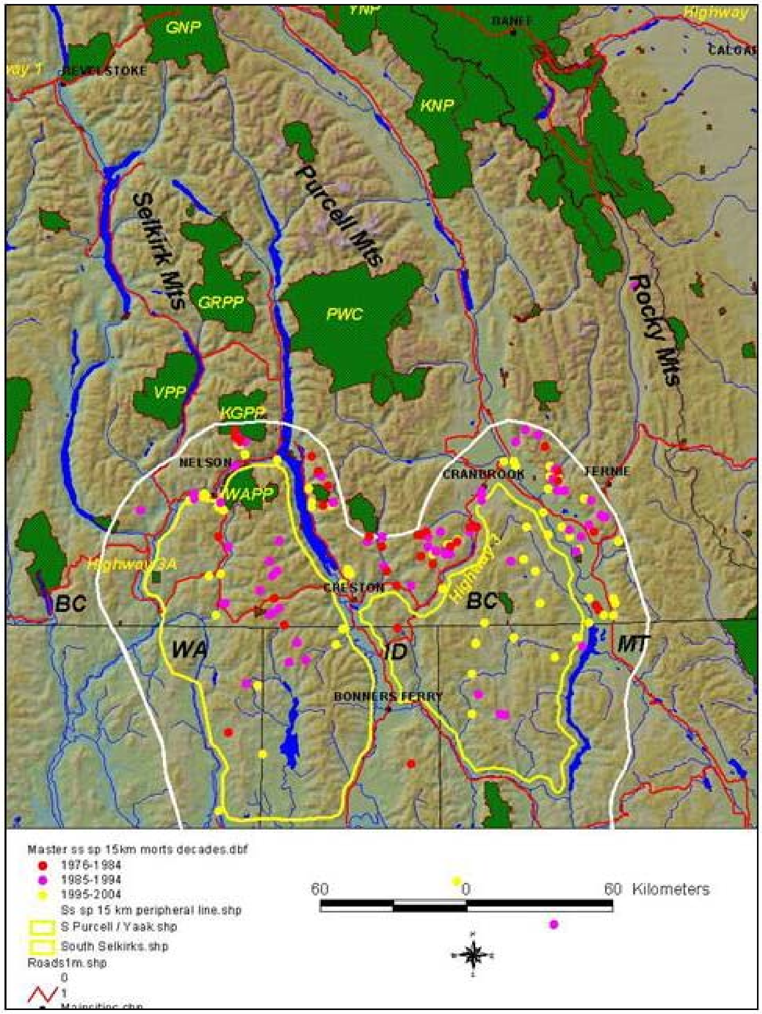
An important question is: what aspects of bear ecology would access management influence? First consider how road densities might affect grizzly bears. The effects of roads on grizzly bear ecology can take several forms. First would be direct habitat loss, and this is likely to be relatively minor. The Yahk GPBU has approximately 2.3 % of its total area in roads (S. Purcell GBPU = 1%). The second effect of roads is related to human-caused mortality and road access. Consider the backcountry mortality rates in the Yahk GBPU: There were 5 known backcountry mortalities in the Yahk GBPU between 1995-2004 (Proctor et al. 2005b, Fig 11), which is 0.5 mortalities annually. When one considers these deaths in light of the population of 20 bears (population estimate from Proctor et al. 2007), this amounts to a 2.5% backcountry mortality rate. McLellan et al. (1999) demonstrated that for every bear that managers know is killed, there is another one killed that is unknown.   Therefore, when you then add on the estimated rate for unknown mortalities in this population, the mortality rate increases to ~5% annually. Five percent is close to the sustainable limit for this population (Austin et al 2004), and this mortality rate does not yet include front-country mortalities. Bear Aware education programs can be an effective program for reducing front-country mortalities that occur in rural communities. Back-country mortalities range from self-defense, to black bear hound hunters mistakenly killing grizzly bears, to unknown causes, making backcountry mortality control more challenging. Access management is one tool that should be considered for controlling back-country mortalities.

The third effect of roads on grizzly bears is through displacement from disturbance. The effect this may have is to reduce productivity of females reducing population reproductive rates. The avoidance of roads that we documented suggests the potential for displacement of females from high quality habitat. Our successful females selected home ranges with higher percentages of unroaded habitat than was available and avoided roads regardless of level of vehicle use. Boulanger (2005), in a study of grizzly bears (16 adult females, 71 bears total) in central Alberta, showed that female bears were negatively impacted as road densities increased. Road densities varied across the Alberta study area providing contrast for comparison of roaded and unroaded areas. He found that adult and sub-adult female survival decreased with increased road densities, and that cub production decreased with increased road density. The effect of displacement on female grizzly bears will be difficult to manage without access control.

Human-caused mortality dominates grizzly bear population dynamics in the region (McLellan et al. 1999) and mortality risk is associated with human access. Achieving habitat security for adult females is a vital management strategy for grizzly bear conservation (Mace et al. 1996; 1999; Gibeau 2000) and often requires mitigation of human access. Access management is one of the cornerstones of grizzly bear management; this mitigation strategy has played an important part in the population recovery within the Yellowstone ecosystem (Schwartz et al. 2002; Pyare et al. 2004). Efforts by our Trans-border Grizzly Bear Project Team have provided the scientific background and analysis of grizzly bear habitat use for the Yahk GBPU. Results from these scientific research efforts are intended to stimulate and underpin discussions of access management strategies among the timber industry (Tembec and others), local hunters and recreationists, wildlife managers from the BC Ministry of Environment, and managers from the BC Ministry of Forests.

Figure 11. Map of human-caused grizzly bear mortalities in the south Selkirk (orange polygon) and south Purcell / Yaak (yellow polygon) ecosystems by decade. Mortalities span both the US and Canada and include a 15 km perimeter (white line). Included are: human-caused mortality between 1976-1984 (red dots), 1985-1994 (pink dots), 1995-2004 (yellow dots). Green shaded areas are protected; PWC is

the Purcell Wilderness Conservancy, GRPP, KGPP, VPP, and WAPP are Goat Range, Kokanee Glacier, Valhalla, and West Arm Provincial Park respectively. Adapted from Proctor et al. 2005b.



In addition to this report, the working deliverables from our research efforts are shape-files depicting the BMUs and polygons of higher quality grizzly bear habitat where access management should be considered to yield positive effects for bears. This report details the creation of these units. Results have been shared among interested parties participating in the larger access management discussion. We have an access management working group (Yahk Access Management Working Group) chaired by M. Knapik (BC MoE), and members representing government (MoF, MoE, B.C. Timber Sales) and the timber industry operating within the Yahk GBPU. This group is having discussions with D. Martin (Cranbrook, BC MoE) who is working on a parallel effort to consider BC provincial-wide access standards, and exploring ways our two efforts might work together. These results have also been shared with the Cranbrook West Access Management Advisory Committee chaired by B. Adair (BC

ILMB), a group of representatives from hunter and backcountry recreation user groups that are essential in this process. It has been requested of these parties, that they consider road closures within the grizzly bear habitat polygons (Fig. 10), and consider which roads would be available to access management from their group's perspective. M. Proctor has offered assistance in understanding and interpreting these results to any group who requests it, and has designed a self-guided power point slide show to assist working groups in this effort.

Successful access management has been applied in the US Northern Continental Divide Ecosystem (NCDE) and the Yellowstone ecosystem. For example, establishing habitat security has been a primary management tool for recovery of the Yellowstone ecosystem (68% core habitat achieved), and this ecosystem has seen a remarkable and documented recovery over the past 20 years (Schwartz et al. 2005). The NCDE (which is currently being assessed for population status) is experiencing a range expansion (C. Servheen pers. comm.). Ten years of access management strategies and implementation in the US portion of the Yahk ecosystem has yielded substantial reduction in the back-country road network (Fig. 12). The Yaak ecosystem, however, has not experienced grizzly bear recovery, and success will likely depend on similar access management strategies being implemented in the Canadian part of this ecosystem. In the U.S. portion of this ecosystem where road access has been managed (Fig. 11b), the resulting road densities are approximately 55% core (habitat > 500m from an open road) per BMU (smaller subdivisions not shown on map), in contrast to the Canadian Yahk's current level of 16%. One big difference between the US and Canadian Yahk system and the Yellowstone and NCDE is the high percentage of protected areas within the latter two areas. Protected status usually affords greater influence over human activities. The dearth of protected areas within the trans-border Yahk system provides an extra challenge to attaining a self-sustaining, regionally connected grizzly bear population.

Limitations

This study is constrained by relatively low sample sizes, imposed by low grizzly bear population numbers. We cannot determine the effects of heavily roaded habitats on grizzly bear survivorship or productivity. These are important metrics when considering the value of access management and there is relatively clear, but not abundant, evidence from other studies concerning these relationships. Our limited sample allows a reasonably fair assessment of grizzly bear habitat use and roads in the S. Purcell Mt. region.

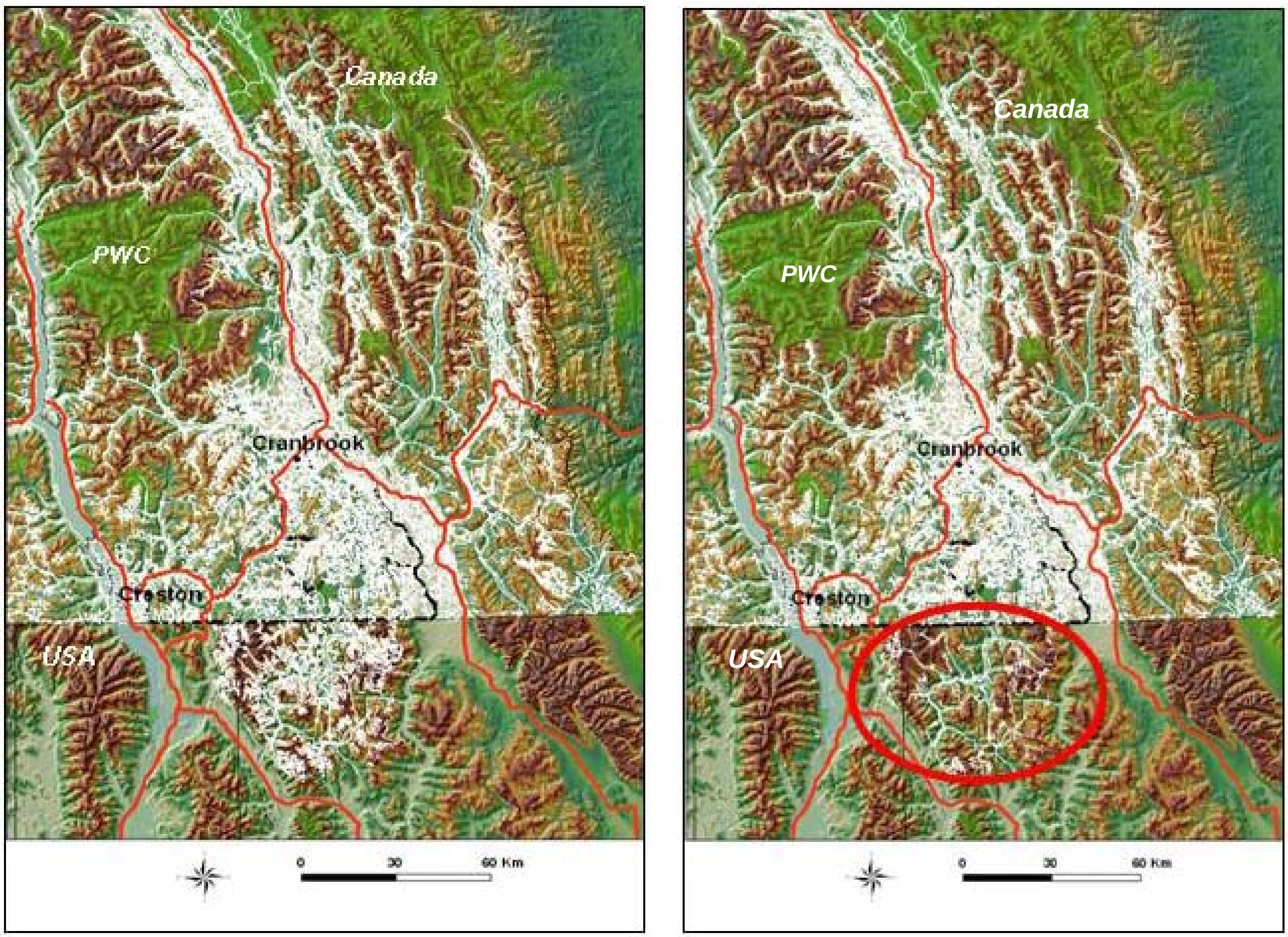
Having captured few females in the Yahk ecosystem, we were unable to model female habitat selection through the seasons. The paradox is that we are trying to understand and predict use of habitat by females in an ecosystem where they are critically low. This situation is exacerbated by the fact that the habitat appears compromised by high road densities. Fortunately, we were able to build a female dataset in areas adjacent to the Yahk GBPU. The use of RSF modeling combing females and males that do use the Yahk GBPU has allowed this analysis.

CONCLUSIONS

There exists a clear case for the fact the grizzly bears are threatened in the Yahk GBPU and that enhanced conservation oriented management will be necessary for recovery to occur. The U.S. has had considerable experience with grizzly bear conservation, management, and recovery over the years, implementing such strategies as reducing excessive human-caused mortality and improving habitat security, particularly for females. Effort north of the international border is needed to complement US efforts, particularly within the trans-border Yahk ecosystem. All facets of grizzly bear management require science-based solutions and cooperation among the many parts of society. This report details the efforts of the Trans-border Grizzly Bear Project's effort to develop science-based solutions for implementing access management in the Yahk GBPU. We have documented avoidance of roaded habitat by local grizzly bears, as has been shown in other systems, and identified polygons of higher quality grizzly bear habitat for consideration by the wider community in a discussion of access management. . By no means can we provide 100% assurance that managing access in the Yahk GBPU will guarantee recovery; we can only use the weight of evidence from our own work and that of other larger studies, together with the experience and advice of those who have accomplished what we are attempting to do here. The Yahk Access Management Working Group chaired by M. Knapik from BC's MoE and the Cranbrook West Access Management Advisory Committee chaired by B. Adair from BC's ILMB, will be the primary vehicles for this community discussion.

Figure 12. Trans-border regional backcountry road network (white lines) a) is all open roads in Canada and all roads in the US portion of the Yahk ecosystem. b) is the same view with only the “open” roads in the US Yahk (red oval). US Roads not shown are closed for access management.

a b



Project objectives

1. Finalize our past linkage research efforts into a Purcell Mt. Hwy 3 Linkage Management Plan that will inform future management to improve connectivity across BC Highway 3.
2. Improve our understanding of roads, access, and grizzly bear habitat use and develop a habitat security strategy for the Yahk GBPU.
    a. Upgrade preliminary grizzly bear habitat model with better road layers that include intensity-of-use information.
    b. Model grizzly bear habitat without the influence of roads to identify ecological characteristics of habitat selection (not based on avoiding humans and roads).
    c. Integrate Tembec planners into the process by prioritizing roads for their management potential.
    d. Integrate local hunter groups and recreationists into the process by prioritizing roads for their management potential.
3. Begin steps to apply habitat security analysis to the south and central Purcell GBPUs (north of Hwy 3).
    a. Do a GIS-based analysis of road and human access in the South and Central Purcell GBPU.
4. **4)** Continue with on-going radio telemetry effort in the 2007 season to improve road, access, and habitat models.

Deliverables for 2007-2008

- ✓ A Purcell Mt. Hwy 3 Linkage Enhancement Plan **COMPLETE, submitted separately before March 30.**
- ✓ A report detailing the *optimization* of a habitat security strategy in the Yahk GBPU for use in implementing appropriate grizzly bear management in relation to the Forest Certification process. **PARTIALLY COMPLETE, for the second year in a row I did not get the requisite parties to weigh in on their selections for access management. I realize that this is beyond my sphere of influence. I can provide the working materials identifying higher quality grizzly bear habitat to ultimately optimize the process, but having the stakeholder groups select roads they are willing to close is a longer term process, likely years.**
- ✓ Male and female seasonal RSF models. **COMPLETE**

- ✓ Road density analysis – core habitat of females **COMPLETE.**
- ✓ Radio telemetry work complete for our 4th season, collars deployed on grizzly bears, collars collected in fall, data downloaded and integrated into project database. **COMPLETE**
- ✓ Analysis of road density and intensity of use for the south and central Purcell GBPUs north of Hwy 3 **COMPLETE**

TEMEBC 2007-2008 budget

		Budget	Actual
Linkage, Roads, access, habitat modeling			
Final Linkage Enhancement Plan		5000	6000
Planning & integration		3000	1000
Optimized Habitat Security Strategy		3000	4000
South and Central Purcell GBPU road and core habitat analysis		2000	2000
Consultation meetings, GIS presentations (maps)		2000	2000
	Sub-total	15,000	15,000
Radio telemetry related work			
Labor			
Collecting, downloading, and formatting data collars		3000	3000
Expenses			
Expenses for summer / fall of 2007		4000	4000
	Sub-total	7000	7000
	TOTAL	22,000	22,000

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