120 Extension Note

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The Relationships among Road Density, Habitat Quality, and Grizzly Bear Population Density in the Kettle-Granby Area of British Columbia

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Preamble

Since time immemorial, the Syilx people of the Okanagan Nation have taken care of all lands, waters, and living things within Syilx Territory, which includes this project's study area. Syilx people have been self-reliant and well provided for through their own ingenuity and careful and considered use of their land and resources. Grizzly bear is known as Kiʔlawnaʔ in N'Syilxcn (the Syilx language). Kiʔlawnaʔ is a part of timix^{w} (all living things) and an integral and critical part of Syilx culture. The grizzly bear is a relative who guides the people and other living things to respect the land and live in health. Semxayqn (female grizzly) is a powerful symbol of mothering, culture, and language transmission. Grizzly bear and the people gather and hunt the same foods; the continued presence of Kiʔlawnaʔ is a strong indicator of healthy land. In 2014, the Okanagan Nation Chief's Executive Council declared Kiʔlawnaʔ to be at risk and in need of protection in Syilx Territory.

– Okanagan Nation Alliance

Grizzly bears are a species of special concern in the province of British Columbia and legislation, policies, procedures, and programs are in place to support the Provincial goal to maintain, in perpetuity, the diversity and abundance of grizzly bears, and the ecosystems on which they depend, throughout British Columbia. This is done by carefully tracking and managing all sources of reported human-caused mortality, estimating unreported human-caused mortality based on the best available research, mitigating conflicts where possible, protecting habitat, studying bear biology and ecology, and informing First Nations, the public, and the scientific community about these activities.

– Ministry of Forests, Lands and Natural Resource Operations

Introduction

During the summer of 2015, we surveyed grizzly bears in the Kettle-Granby grizzly bear population unit (GBPU) to help assess population status and map the distribution of bears within the unit. Our first objective was to estimate the current population abundance and density of grizzly bears and map their summer distribution.

British Columbia

Our second objective was to investigate whether landscape conditions such as habitat quality and road density were related to bear abundance. Based on our results, we provide recommendations for improving the viability of the grizzly bear population in the Kettle-Granby GBPU.

The grizzly population in the Kettle and Granby River valleys of southern British Columbia is considered threatened due to the low number of bears relative to the habitat suitability of the area, and because the population may be poorly connected with other grizzly populations (Figure 1). Grizzly bears are rare in the Okanagan Valley to the west and in Washington State to the south. To the east of the Kettle-Granby population, connectivity with the threatened South Selkirk population and the viable Valhalla population is likely poor due to the presence of the cities of Castlegar and Trail, and the Arrow Lakes farther north. We suspect population connectivity of the Kettle-Granby population to other grizzly bear populations is mainly to the north across Highway 6 in the Monashee Mountain Range.

The Kettle-Granby grizzly population faces several distinct threats, including poor habitat suitability in much of the area, high levels of forestry activity and other human use of the landscape, and increasing human-caused mortalities. Habitat suitability mapping by Gyug and Hamilton (2007) identified little medium or high suitability habitat in the area, and in recent years, habitat suitability has been further reduced by road expansion (Lamb et al., in press). Despite encompassing three large provincial parks (Granby, Gladstone, and Graystokes), the area has some of the highest road densities in British Columbia. Research suggests that high road densities, when combined with high traffic volumes, may reduce the effectiveness of grizzly bear habitat because bears avoid potential feeding sites due to human presence (Mace et al. 1996; Northrup 2010). In addition, human-caused mortality of bears may increase with road density because human–bear encounters increase (Schwartz et al. 2010; Boulanger and Stenhouse 2014). In the Kettle-Granby population unit, there were 0.6 reported grizzly bear control kills per year between 1978 and 1993, but reported grizzly control kills increased to 1.5 per year between 1994 and 2009. Assuming that grizzly bear mortality reporting rates have not changed, this increase in control kills could be a result of an increasing grizzly bear population or an increasing human–bear encounter rate due to increasing road access and human use of roads (Stent 2011).

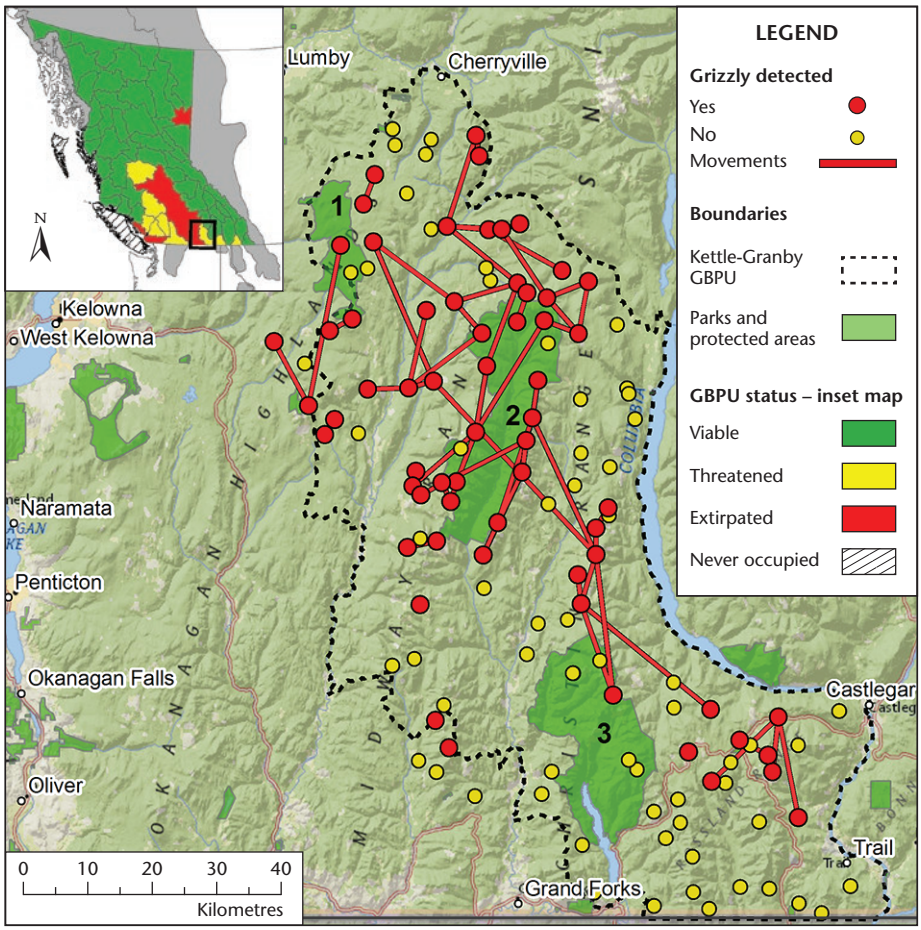

FIGURE 1 *Map of the threatened Kettle-Granby grizzly bear population unit (GBPU) showing the location of the 129 hair sampling sites used in summer 2015, and the movements of bears detected at more than one site. We assume straight line movements between detection sites, which is an oversimplification; it is more likely that bears followed higher suitability habitat while travelling. Large provincial protected areas include: 1) Graystokes Protected Area, 2) Granby Park, and 3) Gladstone Park.*

The only previous inventory of this population was conducted in 1997 and produced an estimate of 38 bears (lower estimate of 23; upper estimate of 53) (Boulanger et al. 2002). More recently, Stent (2011) gathered and summarized available sighting and kill data for grizzly bears within the Kettle-Granby population unit, and suggested that the population had expanded its distribution eastward since the late 1990s. Stent (2011) speculated that the population was likely increasing, but could not be sure because sighting data were biased by access; for example, few bears were observed in Granby Park where human access is limited.

First Nations, environmental groups, and the public are concerned about the conservation status and recovery of the Kettle-Granby grizzly population, and this concern has fuelled debate about forestry practices in the area. A population inventory was seen as a first step in resolving this debate because its findings could help clarify the conservation status of the population and aid in prioritizing local management actions based on the documented distribution of bears.

Study Area

The Kettle-Granby GBPU extends from the international border in the south to Highway 6 in the north, and it is bounded by the Kettle River on the west and Lower Arrow Lake on the east. The Kettle-Granby grizzly bear population occurs entirely within the Selkirk Bitterroot Foothills Ecoregion and the Selkirk Foothills Ecosection. Biogeoclimatic zones in the area include the Interior Cedar–Hemlock, which occurs most frequently at low elevations (600–1600 m), and the Engelmann Spruce–Subalpine Fir, which dominates at higher elevations (>1700 m). The Interior Douglas-fir zone occurs at low elevations (800–1200 m) in the southern portion of the area. Terrain is variable; high plateaus and rolling hills are common in the southern half of the GBPU, while the northern half of the unit is more mountainous. Subalpine parkland is common at high elevations, but alpine meadows and avalanche chutes are rare. Land use is mostly agriculture in the south and west, and is dominated by commercial forestry elsewhere, except in the three provincial parks.

Methods

To collect hair samples for the survey, we used a variety of scent lures to attract bears to hair snag sites. We identified individual bears from genetic fingerprints of viable hair samples using a genetic analysis procedure in a laboratory. Between June 15, 2015 and August 19, 2015, we set lured hair snag sites throughout the Kettle-Granby GBPU and checked them for hair samples four times at 2-week intervals. We monitored a total of 124 sites (96 ground access sites and 28 helicopter access sites) throughout the summer (Figure 1).

We used 3–4 L of rotten cow blood and ½ L of putrefied fish oil to lure bears to sites. We poured the lure over a pile of woody debris in the centre of each site. We attached barbed wire, at a height of 50–60 cm above the ground, to trees surrounding the lure pile. We were careful to leave at least 1 m between the barbed wire and the lure pile so bears would have to go under or over the wire to investigate the pile. Each time a site was checked, we refreshed the blood and fish oil and added a new scent as an additional attractant. The novel scents included beaver castor, anise oil, and skunk essence.

Efford and Boulanger (2015) conducted a simulation exercise specific to the Kettle-Granby grizzly bear population to evaluate various sampling designs based on the goals of maximizing both cost efficiency and precision of the bear density estimate. Simulation results suggested that employing about 125 hair snag sites would achieve acceptable precision, and moving sites between sampling sessions did not improve precision. Some clumping of hair snag sites did not reduce precision and offered considerable cost saving because the cost of accessing sites is a large part of the total field cost.

Based on these results, we established the following rules when setting sites:

- Overlay a grid of 49-km² cells on the study area, and install a maximum of two sites per cell.
- Maintain a minimum distance of 2 km between sites.
- Allow a maximum of two adjacent cells without sites.
- Do not move sites between sessions.

Bear lure sites are designed to look like a place where a bear or cougar has buried an animal carcass because bears commonly scavenge carcasses. We pile up debris and pour blood and fish oil on top of the debris to attract bears to the site. Bears have an exceptional sense of smell and have been observed to approach a site from more than 1 km away. There is no food reward at the site, and bears typically spend only a few minutes at the site moving around the pile of debris and may leave hair snagged on the surrounding barbed wire. Many thousands of these sites have been set in British Columbia over the last 20 years, and there have been no reported safety incidents. (Photo: Clayton Lamb)

- New sites could be added in any session.

Genetic analysis was conducted by Wildlife Genetics International (Nelson, B.C.). Hair samples were visually sorted to remove samples with shiny black guard hair, which were assumed to be black bear. Hair samples that did not appear to be from a bear, or hair samples that had no guard hair or fewer than 10 underfur, were not analyzed.

We used spatially explicit capture–recapture models (Efford and Fewster 2013) to estimate the density of grizzly bears in the Kettle-Granby GBPU. These models have become the standard method for analyzing demographically closed capture–recapture data. This analysis method also enables the user to statistically test for environmental factors that may be related to grizzly bear density. For example, we were particularly interested in knowing if grizzly habitat suitability or road density was related to grizzly bear density. We summarized habitat suitability and road density across the study area using a 16-km diameter (i.e., 201 km²) moving window analysis in ArcGIS 10.3 (ESRI, Redlands, CA, USA). We chose to use a moving window because we believed the presence of a bear is determined by the landscape characteristics of its entire home range, not just the centre. We used a 16-km diameter window because we felt that was likely the average seasonal range size for a bear living in our study area, given that the annual home ranges for grizzly bears elsewhere in southern British Columbia are generally 200–1000 km² (16- to 36-km diameter, assuming circular ranges). Females have smaller home ranges than males, and ranges are larger in areas of poorer habitat (Graham and Stenhouse 2014; McLellan 2015).

Habitat suitability ratings were developed for map units of the Broad Ecosystem Inventory. Each map unit was subjectively rated by bear habitat experts for quantity of plant forage (one to six classes) based on abiotic features such as climate, geology, terrain, and physiography, and biotic features such as climax forest type and current vegetation or seral stage (Gyug and Hamilton 2007). We selected the highest seasonal rating for each map unit (Figure 2a). The average map unit size was 2098 ha, and size varied from 37 to 34 637 ha. Mortality risk and disturbance effects on habitat effectiveness were not included in the suitability rating. This work was conducted between 1995 and 2000, and hence reflected vegetation conditions prior to that date; therefore, recent landscape changes such as fires and logging are not reflected in the suitability ratings.

We calculated road density using provincial road data (Figure 2b), and created a GIS layer to identify areas that had less than or greater than 0.6 km of road/km² (Figure 2c). This threshold was based on guidelines from the United States and work done in Alberta that suggested that grizzly bear demography is compromised at road densities that exceed 0.6–0.75 km of road/km² (Mace et al. 1996; Boulanger and Stenhouse 2014). We tested the effects of roads and road closures simultaneously by creating a road density measure based only on roads that were open to motor vehicles (Figure 2d); thus, we removed all roads that were closed (Figure 2e and 2f).

High suitability grizzly bear habitat, such as this alpine meadow in Granby Park, are used by bears in spring and summer. Bears forage on grasses and forbs, such as Sitka valerian (*Valeriana sitchensis*), as they green-up. Newly emerging plants are less woody and easier for bears to digest than are older plants. Grizzly bears may also dig for the roots of glacier lily (*Erythronium grandiflorum*) or sweet-vetch (*Hedysarum* spp.), both of which are high in starch and easily digestible. In late summer or fall, bears may also dig sleeping ground squirrels (*Spermophilus columbianus*) or marmots (*Marmota caligata*) from their dens, or forage on whitebark pine (*Pinus albicaulis*) seeds that have been cached by Clark's Nutcrackers (*Nucifraga columbiana*) or red squirrels (*Tamiasciurus hudsonicus*). (Photo: Clayton Lamb)

Results and Conclusions

We detected grizzly bears at lured sites 177 times. During the study, five additional detections were collected opportunistically from rub trees, and one additional sample was obtained from an illegally killed female bear. We identified 74 individual grizzly bears (38 males and 36 females) at our lure sites. We detected two long-distance movements, both of which

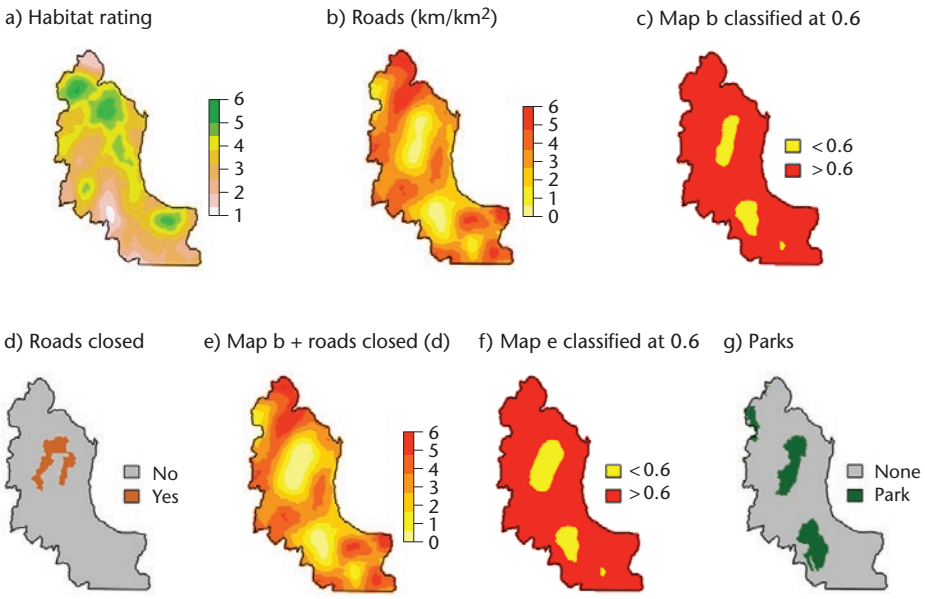

FIGURE 2 *Maps showing the factors we hypothesized may be related to grizzly bear density in the Kettle-Granby grizzly bear population unit. Habitat rating and road density were averaged in 16-km diameter windows, which was roughly the size of a female home range. Figures 2c and 2f classified each map unit as either less than or greater than 0.6 km of road per km². This threshold was based on previous research and management guidelines currently in place in British Columbia and elsewhere.*

were based on locations of individuals that were first detected in years previous to our study. We suspect that these were movements by animals that had established their adult home range some distance from their natal range. In one case, a male bear was caught as a sub-adult in 2014 in the Selkirk Range south of Nelson, and then one year later was detected 53 km west on the west side of the Columbia River in our study area. The other bear was a female that was detected in our study area in 2010 and then was detected 30 km away during our sampling in 2015.

Our estimate of grizzly bear population size in the Kettle-Granby GBPU was 87 bears (lower estimate 68; upper estimate 110), whereas the 1997 population estimate was 38 bears (lower estimate 23; upper estimate 53) (Boulanger et al. 2002). We detected bears over a much larger area in 2015 than during the inventory in 1997 (Boulanger 2000; Stent 2011). Our data suggest that the grizzly bear population in the Kettle-Granby area increased in size and expanded its summer range between 1997 and 2015. We did not detect bears near human population centres such as Rossland, Edgewood, and Lumby; however, these areas all had moderate habitat suitability with high road density. Nearly all areas rated as high suitability habitat were occupied in summer, so any further expansion of the population will be into medium- or low-rated habitat.

Few bears were detected in the southwest portion of the study area, which is the driest part of the study area and had the lowest habitat suitability (Figure 2a). Surprisingly, few bears were detected near Rossland in the southeast portion of the study area, despite relatively high habitat suitability. We detected only two movements between the Gladstone Range in the east and the Granby Range to the west. While it is impossible to know a travel route from two disparate locations, it is likely these individuals, who were both males, crossed well north of Gladstone Park in upper Burrell Creek. Our data also demonstrate that male grizzly bears move across the upper Christian Valley regularly in summer. The connectivity of the Kettle-Granby grizzly population to the larger interior population is via the Monashee Mountains to the north. While the number of bears living near the boundary between the two populations is relatively large, the contiguous zone is only about 50 km wide. Maintaining or improving the ability of bears to move across Highway 6 is important to the long-term survival of the Kettle-Granby grizzly bear population.

Population genetic analysis conducted by David Paetkau in 2014 suggested that bears currently living in the Kettle-Granby area have not been genetically isolated in the recent past (D. Paetkau, Wildlife Genetics

Black huckleberry (*Vaccinium membranaceum*) produces berries that are relatively sweet and clumped on each bush. Production varies greatly among years, but during good years, bears can gain enough fat for their winter hibernation by eating these berries alone. In many landscapes, the most productive and more permanent berry patches occur in old burns near the treeline. These sites have been known to persist for nearly 100 years. Good berry patches can also be found in recent cutblocks; however, grizzly bears quit foraging in berry patches once the canopy has closed over because the patches produce fewer berries that are less sweet than berries grown in the open sun. (Photo: Clayton Lamb)

International, pers. comm.). Genetically, Kettle-Granby bears were most similar to bears living in the adjacent Monashee Mountains. Paetkau detected the movement of two male bears between the South Selkirk and the Kettle-Granby population units. He also detected movements of two male bears between the Kettle-Granby population unit and the Central Monashee unit north of Highway 6. One of these bears even moved into Washington State. Hence, at least six movements of male bears into the Kettle-Granby population have been documented in the last decade, which supports the conclusion that this bear population is neither genetically nor demographically isolated.

We found a positive relationship between grizzly bear density and habitat suitability, and a negative relationship between grizzly bear density and road density (Figure 3). The relationship between habitat suitability and bear density was expected and is a reminder that it is advantageous to focus recovery efforts in areas of better habitat. In our study, areas with low road density had triple the bear density of areas with high road density (Figure 3b). This negative relationship with roads has been documented elsewhere (see Boulanger and Stenhouse 2014 for a recent review) and can be explained by increased mortality near roads or avoidance of roads by bears. We cannot separate these two factors in our analysis; however, the way to manage either factor to benefit grizzly bear populations is to reduce human use of roads or remove the roads entirely, particularly in areas of good bear habitat.

Grizzly bear density varied substantially across the study area. Bear density in the grassland area between Grand Forks and Rock Creek and in the lower Granby and Kettle River valleys was very low; our model predicted densities close to zero for these areas (Figure 4). These grassland areas will likely only ever support transient grizzly bears in spring or fall; resident bears are unlikely to occur in these areas. In contrast, the mean grizzly bear density for areas with low road density (< 0.6 km of road/km²) was about 30 bears/1000 km² (Figure 3b), which is indicative of moderate habitat suitability relative to other areas of the British Columbia interior (Mowat et al. 2005; Mowat et al. 2013). In our study area, areas with high road density (> 0.6 km of road/km²) had a mean bear density of fewer than 11 bears/1000 km² (Figure 3b), which is similar to densities recorded in boreal areas of the species' range (Mowat et al. 2013). This low bear density is likely a result of both lower habitat suitability and relatively high human-related effects. It is important to note that we expect our model to be less accurate at predicting bear density when extrapolating beyond our study area. For example, our model is tuned to the conditions in the area sampled, but traffic volumes are likely higher in the Okanagan Valley, which may render the habitat near roads less effective there than in the Kettle-Granby population unit. Figure 4 may thus overestimate the potential density of grizzly bears in the Okanagan Valley.

We found that treating roads in access closures as not present was positively related to grizzly bear density (Lamb et al., in press.). Furthermore, the model that excluded closed roads had slightly better fit than all other models. These results suggest that the current road closures in the Kettle-Granby population unit may have allowed an increase in grizzly bear density and were an effective population recovery tool. Closing roads in high suitability habitat will have the greatest positive effect on grizzly bear density, but road closures may be advised in low suitability habitat in order to connect isolated areas of good habitat with the more continuous distribution of bears.

We compared the importance of roads versus parks to grizzly bear

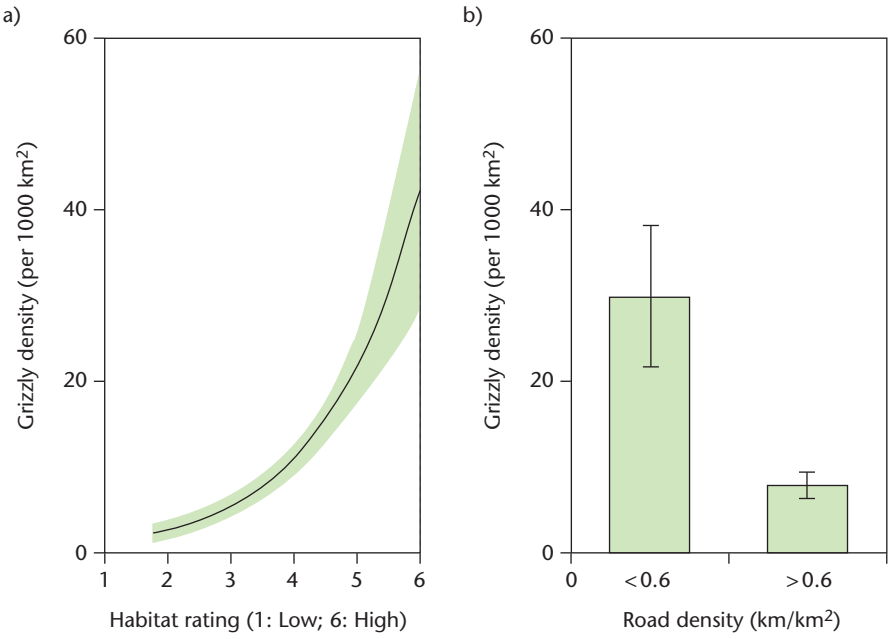

FIGURE 3 *The relationship between grizzly bear density as predicted by our model and habitat rating and road density. (a) Road density was held at the average measured across the study area to control for the variable effect it could have when predicting the influence of habitat quality on grizzly bear density. (b) Habitat rating was held at the average for the study area when predicting the influence of road density.*

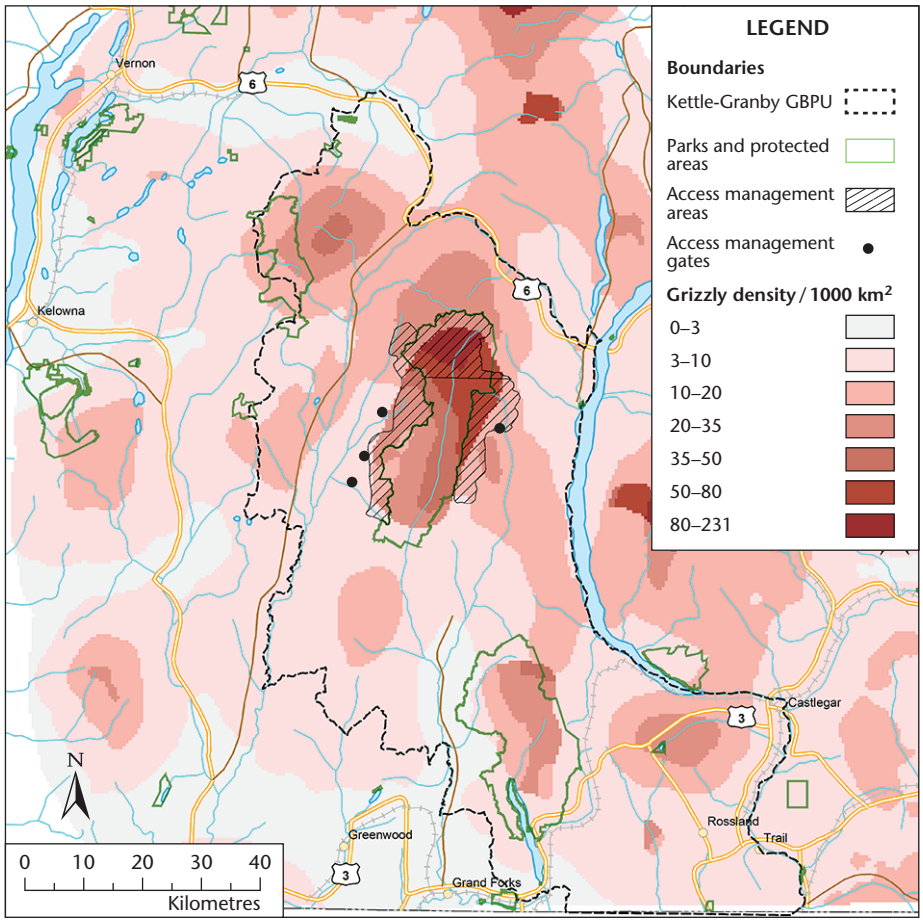

FIGURE 4 *Grizzly bear density as predicted by our model, based on current conditions on the landscape, for the Kettle-Granby population unit and surrounding areas. This is a presentation of observed density within the study area, but also a display of predicted density (generated using the model we built to analyze our data) for areas outside the population unit. To the west of our study area, where the landscape is currently unoccupied by resident grizzly bears, the model is an extrapolation and suggests potential grizzly bear densities.*

density by including a variable in our model that measured whether a site was in or out of a provincial park. While we found that bear density was higher inside parks, the model that included the park variable did not fit as well as the model with road density, which implies that roads are more strongly correlated with bear density than are parks. This observation suggests that areas of low road density and high habitat suitability outside of parks can also have high bear density. Although the highest estimated bear density in our study area was in Granby Park, the parks comprise relatively small portions of the landscape. Currently, only 30% of the bears that are estimated to reside in the Kettle-Granby GBPU have most of their home range in a park, and most of these bears are in Granby Park (Table 1).

Strategically, it would make most sense to target habitat recovery in areas of the highest habitat suitability while also making an effort to join areas of high bear density with areas of low road density so that bears can move among these nodes with low risk to their safety (Figure 5a). Furthermore, if all other things are equal, targeting areas that have lower road density will simplify the implementation of closures (Figure 5b).

Management Recommendations

- Reassess the status of the Kettle-Granby grizzly bear population using this new information on population size, density, distribution, and population connectivity.
- Implement access closures to improve connectivity among subpopulations, increase bear density, and expand the distribution of the population (Figure 5). The focus should be in or adjacent to high- or medium-quality habitat. Areas where access closures have the potential to most benefit the bear population include, in order of decreasing importance: (A) the area directly north of Granby Park to Highway 6 (this will also increase connectivity with the Monashee

Buffaloberry (*Shepherdia canadensis*) also has relatively sweet berries, though they taste bitter to most people. Other names for this shrub are soapberry and soopolallie, and First Nations often call it xoosum or hooshum. These fruits are also sufficiently clumped that grizzly bears can eat enough per day to gain weight. This weight will usually be stored as fat and burned in winter during hibernation. Buffaloberries are ripe in July, before huckleberries, and are the first high-sugar food that bears eat most years in southeast British Columbia. Buffaloberry grows in dry, well-drained sites, and like huckleberries, the best berry production occurs where there is no tree canopy to shade the bushes. Gravel bars in rivers often have highly productive and reliable stands of buffaloberry because the plants get water from the water table below the stream, and gravel bars are well-drained and often in full sun.
(Photo: Clayton Lamb)

TABLE 1 *Density estimates for areas within the Kettle-Granby grizzly bear population unit. Lower and upper estimates (95% confidence intervals) are in parentheses.*

Name	Area (km^2)	Abundance	Density (bears/1000 km^2)
Outside protected area	5674	61 (46.1–80.1)	11 (8.1–14.1)
Gladstone Park	395	6 (3.3–9.3)	14 (8.4–23.6)
Graystokes Park	120	2 (1.4–2.7)	16 (11.7–22.6)
Granby Park	411	18 (11.5–28.9)	44 (27.9–70.2)

bear population), (B) Graystokes Park and the area northeast of Graystokes Park, (C) the Paulson Pass area southwest of Castlegar, and (D) the Gable Mountain area south of Granby Park.

- Implement access closures to improve connectivity between grizzly bear habitats (Figure 5). The focus should first be on linking currently occupied habitats, and then linking unoccupied areas to currently occupied areas to encourage recovery in unoccupied areas. Areas where road closures would improve connectivity include, in order of decreasing importance: (1) north of area "A" (described above) to Highway 6, (2) along the height of land north of Gladstone Park to roughly Bear Paw Lake, and then west through the Tenderloin and Gloucester drainages toward Granby Park, (3) east of Gladstone Park to the Paulson Pass area, (4) between the north end of Granby Park and area "B" (described above), (5) northwest of Bear Paw Lake, through the McFarlane drainage, to the current access area east of Granby Park, and (6) northeast of area "B" (described above) to Highway 6.
- If recovery of grizzly bears into the Okanagan Highlands is a goal, it would be most effective to restrict vehicle access in the area around Lower Barge Lake to try to encourage recolonization of the area by female bears. Consideration would also need to be given to connecting this area to the area around Big White Mountain. Another area that could support a modest density of bears is the area around Solco Lake northeast of Oliver. Providing connectivity for this area using access closures would be difficult because it is well removed from all areas where we detected bears, and all of the area currently has high road density.
- There are many possible ways to close a road to benefit grizzly bear conservation. The best method is the one that results in no motorized traffic (including motorbikes and all-terrain vehicles) on the road. However, we have seen many places where roads that are in poor shape but still passable to vehicles have low enough traffic volumes that bears use the roads frequently for travel. The important point for bears is to reduce traffic volumes to a level such that encounters with armed people are very rare, and vehicle disturbance of feeding bears happens less than once a day. Deactivation or barriers on the lower end of a road network are likely to be effective only if vehicles cannot access the upper end of the road network elsewhere. Winter road closures are not necessary for bears, but the closures must continue through the entire fall because most human–bear conflict and mortality happens in fall. Seasonal closures may be helpful in known seasonal feeding areas, such as south-facing avalanche chutes in spring or huckleberry patches in late summer and early fall.
- Habitat improvement would also help recover the grizzly bear population. Creating huckleberry

Grizzly bears in interior British Columbia can be any colour from light brown to flat black, although the most common coloration is brown with silver-tipped hair over the head and shoulders and sometimes the upper back. Cubs are often more silver than adults. This breeding pair was photographed in the Flathead Valley in May, just before their spring molt when they lose much of their underfur. Note the wider head and much larger size of the male on the left. (Photo: Troy Malish)

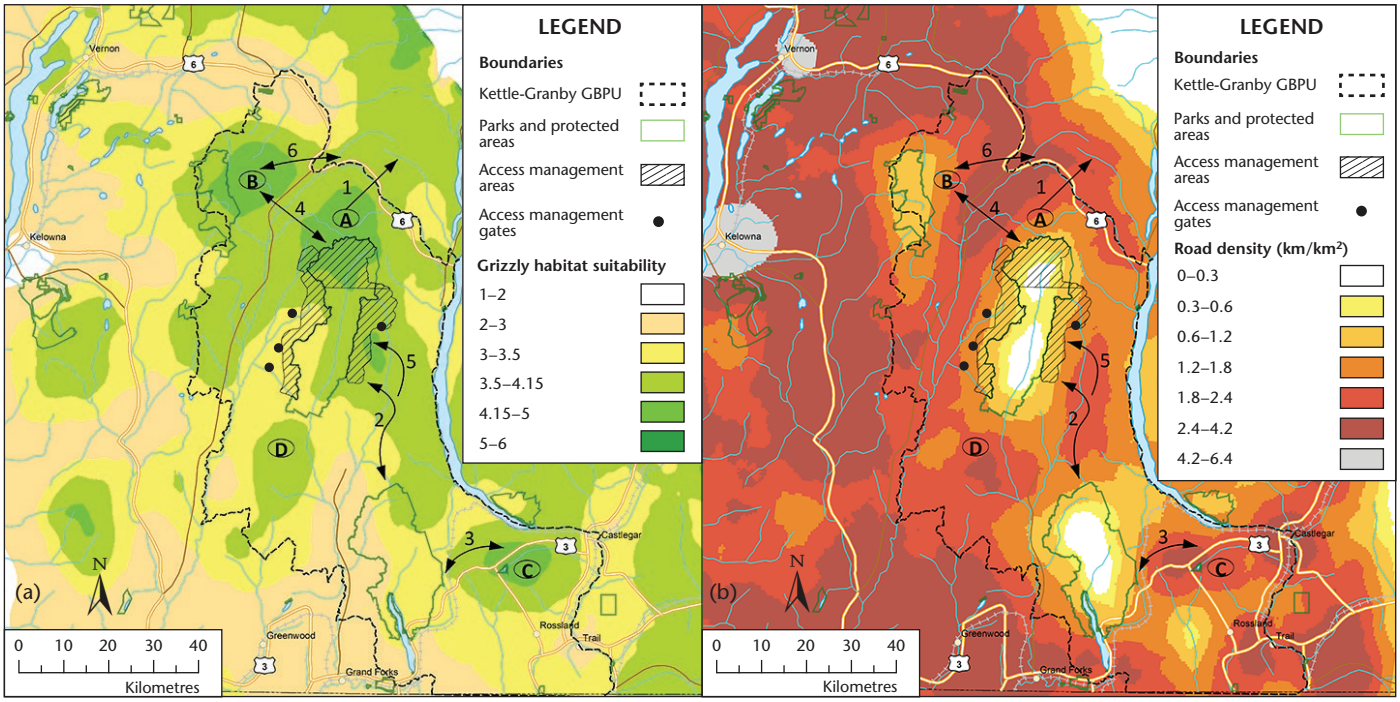

FIGURE 5 *(a) Grizzly bear habitat suitability (higher numbers denote higher suitability); (b) road density (smoothed using an 8-km radius window). Access recommendations are denoted as ellipses for areas targeted at increasing bear density, and arrows are used for areas targeted at increasing connectivity between and within the population unit. Lower letters or numbers indicate higher priorities.*

(*Vaccinium membranaceum*) fields is probably the most effective way to increase bear numbers. The most productive and long-lasting huckleberry fields are created by hot wildfires near the treeline because these sites get much sunlight and regenerate to forest very slowly. Some high-elevation berry fields are nearly permanent because fire consumed most of the soil, which favours huckleberry plants over trees, at least until soil develops again. Cutblocks may also regenerate to huckleberry in certain ecosystems; this process can be encouraged by broadcast burning the block after harvest. Huckleberry production in cutblocks declines rapidly as the canopy closes, so these sites are more ephemeral. A more general habitat enhancement method would be to target new logging in wetter areas that are likely to regenerate to forbs or shrubs, and to close access to these blocks when timber extraction is finished.

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Road density is a surrogate for both human-caused mortality and disturbance to grizzly bears. This photo shows roads built by the forest industry in the McRae Creek area east of Christina Lake. The view is looking north across Highway 3 near the Paulson summit. The actual effect of roads depends on the amount of traffic on the roads and whether the people on the roads have guns with them, and hence, might kill a bear if there is a conflict. Accidents with cars and bears are extremely rare on backcountry roads, but they are becoming more common on highways in some parts of British Columbia. (Photo: Clayton Lamb)

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