Grizzly Bears and Forestry: Increased Mortality Leading to Lower Abundance in Heavily-roaded Landscapes

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Extended Abstract: Both human-caused mortality and food are recognized to be the primary determinants of the distribution and abundance of grizzly bears (*Ursus arctos*); however, before our study, there was no information on the ecology of grizzly bears in the arctic watershed of central British Columbia (B.C.). From 1998 to 2002, we monitored habitat use and survival of 59 radio-collared grizzly bears (n = 37 females, n = 22 males) in an area surrounding the Parsnip River in central-eastern B.C. The 18,100-km^2 study area encompassed a heavily timber-harvested plateau and an adjacent relatively pristine mountainous region. Thirty of the radio-collared bears were from the plateau (n = 19 females, n = 11 males); 29 (n = 18 females, n = 11 males) were from the mountainous region. We asked whether grizzly bears were less abundant in a heavily human-modified landscape (plateau) than in a relatively pristine landscape (mountains), and if so, why?

A DNA population estimate concluded that mountain bears lived at a density of 49 bears per 1000 km^2, while plateau bears lived at a density of 12 bears per 1000 km^2 (Mowat et al., in press). This was a > 4-fold density difference between the two adjacent landscapes. Capture data indicated that adult plateau bears were heavier than adult mountain bears (spring captures: $\bar{x}$ = 127 kg vs. 85 kg females, $\bar{x}$ = 266 kg vs. 126 kg males; fall captures: $\bar{x}$ = 171 kg vs. 121 kg females, no male captures), and were in better condition (57% of plateau bears were in good to excellent condition at capture as opposed to 24% of mountain bears). Adult female mountain bears also spent an average of 36 days longer in their dens than adult female plateau bears (Ciarniello et al., in review). This translates to approximately one month less foraging opportunity for female bears that lived in the mountains (foraging season: $\bar{x}$ = 201 days plateau, $\bar{x}$ = 165 days mountains).

We were able to determine the age of first reproduction for three female plateau bears: one bred at four years of age, and two bred at five years of age ($\bar{x}$ = 4.3 years). We also monitored

[1]NatureServe Explorer (version 4.0, July 2004) lists *Ursus arctos* as the brown bear, and *Ursus arctos horribilis* as the grizzly bear.

bears that never produced cubs. We monitored two mountain bears (ages 8–12 and 9–14 years) for five and six consecutive years, and one plateau bear (aged 5–8 years) for four years; thus, although potential primiparity was four years, average age of first reproduction was higher. Average litter size was two cubs ($\bar{x}$ = 1.92 cubs per litter, n = 13, mountains; $\bar{x}$ = 2.0 cubs per litter, n = 7, plateau). Cub-of-the-year mortality was 36%, and varied by landscape (63% mortality, n = 19, mountains; 0% mortality, n = 13, plateau). For both landscapes, age at which offspring became independent varied from two to four years of age (n = 11 family groups: plateau = 4, mountains = 7). No bears became independent earlier than two years of age in either landscape.

During the non-denning season, randomly selected bear telemetry locations were visited within 1–14 days. Bear foraging was the primary activity identified at 385 of the 538 sites visited. We found that plateau bears foraged more on berries and scavenged or hunted more moose and ants than mountain bears which dug more for microtines, rodents, and plant roots/bulbs of plants (χ^2 = 6.29, $P < 0.05$). Supporting these results, stable isotope analysis on bear hair gathered during captures, site investigations, and the DNA sampling grid revealed that meat/ants comprised 2–4% of the diet of mountain bears as opposed to 20–40% of the diet of plateau bears (as measured in parts per thousand ($^{o}/_{oo}$) $^{15}N/^{14}N$ ratio of sample to atmospheric nitrogen: mean $\delta^{15}N$ = 5.2$^{o}/_{oo}$ plateau vs. 3.4$^{o}/_{oo}$ mountains). When compared to mountain bears, plateau bears were in better condition, had a longer foraging season, consumed up to ten times more meat/ants, and lived at 1/4 the density of mountain bears.

Next, we examined grizzly bear survival to determine what contributed to density differences between the two landscapes. Mean annual survival estimates were calculated using the Kaplan-Meier staggered entry estimator (Pollock et al. 1989). Mean survival rates were 0.97 for mountain bears and 0.79 for plateau bears (mountains: n = 26, number at risk $\bar{x}$ = 59, range 52–73, CI 0.93 to 1.00; plateau: n = 32, number at risk $\bar{x}$ = 36, range 30–44, CI 0.66 to 0.91). Mountain bear survival rates were similar to those reported for the southern Rocky Mountains (McLellan et al. 1999: adult female 0.95–0.96, adult male 0.84–0.89). Mountain bears experienced a 3% mortality rate versus a 21% mortality rate for plateau bears. In other words, plateau bears had a seven times greater chance of dying than their mountain bear counterparts. A report to the B.C. government estimates the sustainable harvest for grizzly bears to be 6% (Peek et al. 2003). Plateau bears cannot sustain a 20% mortality rate, and we conclude that the population must be declining. The low survival rate on the plateau caused us to further investigate grizzly bear deaths in the study area.

High mortality of plateau bears was primarily human caused, while mountain bears died mainly of natural causes. In the mountains, three bears died during monitoring; two (67%) died of natural causes, and one (33%) was shot during the legal hunting season while feeding in a cutblock. On the plateau, 12 bears died during monitoring; 5 (42%) were killed illegally (i.e., the bears were not killed during the legal hunting season by a hunter who had a license), 3 (25%) were legally shot, 2 (17%) died of unknown causes, and 2 (17%) died as a result of problem-

wildlife removals. Overall, 10 (83%) of 12 plateau bear deaths were known to be human caused. There were no known natural deaths on the plateau.

The majority of human-caused bear deaths occurred in the fall (mid-September through mid-November) coinciding with the timing of hunting for other game species such as moose and grouse (spring deaths = 3 plateau, 2 mountains; summer deaths = 1 plateau, 1 mountains; fall deaths = 8 plateau, 0 mountains). No bears died during the winter denning period. For both landscapes combined (n = 15 bears), seven (47%) females and eight males (53%) were killed. In the mountains, two females and one male were killed, while on the plateau, five females and seven males were killed.

We also examined what factors contributed to bear deaths, and found that 7 of the 12 plateau bear deaths that occurred within the study area were within 500 m of a road. Four of the 12 plateau deaths occurred outside the study area, and were, therefore, beyond our detailed GIS layers; however, examination of those deaths revealed that two male bears were legally hunted off secondary logging roads, one was shot on a ranch as 'problem wildlife', and one was shot by a grouse hunter in defence of life. The remaining death occurred within the plateau portion of study area and was reported to authorities along with the bear's ear tag, however, UTM coordinates were not obtained, and the carcass of the bear was not found. All three mountain bear deaths occurred within the study area: the human-caused death was on a logging road, while the two natural deaths were 1 km and 10 km from the closest road. On the plateau, grizzly bears were killed closer to secondary logging roads than primary trunk roads or highways.

To determine if our observed mortality patterns were consistent with previous ones in the study area, we examined the 1977–2002 databases for compulsory inspections. Although this database focuses primarily on the legal limited entry hunt, it also contains all recorded animal-control kills, carcass pick-ups, and illegal kills. Eliminating the legal harvest, on the plateau, all animal-control kills (n = 64), 78% of illegal kills (7 of 9), and 67% of carcass pick-ups (2 of 3) occurred within 500 m of a road. In the mountains, again eliminating the legal harvest, 67% (2 of 3) of the animal-control kills occurred within 500 m of a road; however, of the three bears killed illegally, two were killed 1.5 km and one was killed more than 5 km from a road.

We used resource selection ratios (Manly et al. 2002) to examine habitats selected by bears during the non-denning period. Plateau bears were selecting early seral (0–45 years) habitats for foraging. Bears in the arctic watershed lacked salmon, and relied on foods found in early seral stands, particularly moose, forbs, and ants. Since fire suppression was implemented, the majority of these early seral stages have been created by forestry operations. Forestry operations have also been responsible for an increased number of roads on the landscape, which, in turn, has lead to increased human access, contact with bears, and human-caused bear mortality. Plateau bears existed at a low density relative to their food supply; therefore, per capita food availability on the plateau was higher than in the mountains. This allowed plateau bears to grow bigger and be unselective in their choice of habitat types; however, they were limited below the food-limited

carrying capacity by human-caused mortality. Because mountain bears experienced few human-caused mortalities, we suggest that they constituted a naturally regulated population.

Human-caused bear mortality in our study was related to the density of active roads. Focus must be placed then on reducing densities of active roads if we want to maintain grizzly bears within a 'working forest.' Logging plans that minimize the need for permanent roads should be developed for future harvest areas, thereby providing a perpetual supply of large 'roadless' areas on the landscape. For existing cutblocks, there should be an application of road closures and reclamation on managed landscapes.

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