ROAD AND TRAIL INFLUENCES ON GRIZZLY BEARS AND BLACK BEARS IN NORTHWEST MONTANA

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Abstract: Radio locations from 3 grizzly bears (*Ursus arctos*) and 26 black bears (*U. americanus*) in the Cabinet Mountains of northwest Montana were analyzed to determine the effects of roads and trails on seasonal habitat use patterns from 1983 to 1988. Two seasons, spring and fall, were identified based on food habits and habitat use. Distances from radio locations to the nearest open road and trail were compared to distances from random points to the nearest road and trail. Grizzly bears used habitat 0-914 m from open roads less than expected based on availability during spring and fall ($P < 0.05$). Black bears used habitat 0-274 m from open roads less than expected during spring and used habitat 0-914 m from roads less than expected during fall. Grizzly bears used habitat 0-122 m from trails less than expected during spring and fall. Black bears used habitat 0-122 m from trails less than expected during spring and used habitat 0-305 m from trails less than expected during fall. Habitat availability appeared related to grizzly bear avoidance of trails, and black bear avoidance of roads and trails. Mean distance from grizzly bear radio locations to a seasonally closed road increased when the road was opened ($P < 0.001$), though black bear locations did not ($P = 0.324$). The benefits of road closures in bear management were discussed.

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Avoidance of human activities by wildlife has become an important consideration in habitat management. Human activities in wildlife habitat are often concentrated on roads or trails for resource extraction or recreation. Elk habitat management recommendations include maximum road densities designed to protect important elk habitat (Lyon 1979). Cumulative effects models for grizzly bear calculate reductions in habitat effectiveness because bears avoid various types of human activities (Weaver et al. 1986). This management approach requires delineation of zones of influence and the quantification of the disturbance. The objectives of our analyses were to document and compare seasonal zones of less than or greater than expected use adjoining roads and trails for grizzly bears and black bears in the Cabinet Mountains.

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STUDY AREA

We studied habitat use and population characteristics of grizzly bears and black bears from 1983 to 1988 in the Cabinet Mountains of northwest Montana and northern Idaho (48°N, 116°W). The Cabinet Mountains constitute the southern portion of the Cabinet-Yaak Grizzly Bear Ecosystem. Approximately 90% of the study area was on public land administered by the Kootenai, Lolo, and Panhandle National Forests. The Cabinet Mountains Wilderness encompassed 381 km^2 of our study area at higher elevations of the East Cabinet Mountains.

Elevations in the Cabinet Mountains ranged from 610 m along the Kootenai River to 2,664 m at Snowshoe Peak. The study area had a Pacific maritime climate characterized by short, warm summers and heavy, wet winter snowfalls. The lower, drier elevations supported stands of ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*), whereas grand fir (*Abies grandis*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*) dominated the lower elevation moist sites. Mixed stands of subalpine fir (*Abies lasiocarpa*), spruce (*Picea engelmannii*), and mountain hemlock (*Tsuga mertensiana*) were predominant between 1,500 m and timberline. Mixed stands of coniferous and deciduous trees were interspersed with riparian shrubfields and wet meadows along the major rivers. Huckleberry (*Vaccinium* spp.) and mixed shrubfields were largely a result of the wildfires that occurred between 1910 and 1929. Effective fire suppression since then has virtually eliminated wildfire as a natural force in creating and maintaining berry-producing shrubfields.

Contemporary resource use by humans in our study area includes mineral exploration and extraction, timber harvest, and recreation. The Cabinet Mountains have been closed to grizzly bear hunting since 1974. Hunting seasons for black bear were open during spring (15 Apr-31 May) and fall (ca. 6 Sep-30 Nov). Grizzly bear densities were approximately 1 bear/250-300 km^2 and black bear densities were approximately 1 bear/2 km^2 in the study area (Kasworm and Manley 1988).

METHODS

Bears were trapped with foot snares (Johnson and

Pelton 1980). All captured grizzly bears and selected adult black bears were fitted with radio collars (Telonics Inc., Mesa, AZ) and monitored from the air and ground. Black bear selection emphasized females and geographical spacing in the study area. Ground locations were made by triangulation from a minimum of 3 points. Grizzly bears received real time motion-sensitive radio collars. All radio locations were obtained during the day, though some monitoring occurred at night to determine activity patterns. Radio locations at den sites were omitted from the analysis. Locations were plotted on 1:24,000 U.S. Geological Survey (USGS) topographic maps and classified by grizzly bear habitat component (Christensen and Madel 1982, Servheen 1983) and elevation. Distance measurements from open roads and trails to radio locations were made on the USGS topographic maps to 30 m accuracy. Roads closed to vehicles were classified as trails for the analysis. If open roads were closer to bear locations than the nearest trail, the distance to the road was also used as the measurement for the nearest trail. Locations within the zone of less than expected use for roads were eliminated from the trail analysis to avoid bias.

Habitat availability estimates were developed through random point techniques described by Marcum and Loftsgaarden (1980). Use-availability analysis followed techniques described by Neu et al. (1974). Statistical significance was accepted at the 0.05 probability level. Minimum convex polygon home range techniques were used to calculate the area sampled for habitat availability (Hayne 1949). The area sampled was a 1,087-km^2 polygon defined by the range of all grizzly bear locations from the portion of the Kootenai National Forest in which habitat components had been mapped. Availability of habitat was estimated from 1,200 random points within the polygon. Distance to road and trail, habitat component, and elevation were recorded at random points and radio locations. More than 95% of the black bear radio locations fell within this polygon. The random point sample was used to delineate distance-to-road categories (DRC) and distance-to-trail categories (DTC). Twenty percent of random observations produced 5 DRCs: (1) 0-274 m; (2) 275-914 m; (3) 915-1,859 m; (4) 1,860-3,322 m; and (5) >3,322 m. Similarly, 20% of random observations produced 5 DTCs: (1) 0-122 m; (2) 123-305 m; (3) 306-610 m; (4) 611-1,128 m; and (5) >1,128 m.

Habitat use and food habits data from both species were used to determine appropriate seasonal stratification (Kasworm and Manley 1988). Most obvious differences occurred during mid-summer when berries ripened and bears shifted from a grass and forb dominated diet to one composed largely of berries. Two seasons were designated: spring, den exit through 31 July; and, fall, 1 August through den entry.

RESULTS

Radio locations of 3 adult grizzly bears (2 males and 1 female) and 26 adult black bears (9 males and 17 females) were analyzed to determine the effects of open roads and trails. We obtained 317 grizzly bear locations and 1,647 black bear radio locations.

Road Influences on Grizzly Bears

Of the 317 grizzly bear locations, 233 were from the air and 84 were from the ground. A significant difference was detected in grizzly bear use of the 5 DRCs between aerial and ground locations ($X^2 = 31.65$, 1 df, $P < 0.001$). Ground locations were usually obtained when animals were closer to roads and were omitted from further analysis.

Seasonal Variation. — Spring (n = 134) and fall (n = 99) use of the 5 DRCs was not significantly different ($X^2 = 5.46$, 1 df, $P = 0.243$). Therefore spring and fall locations were pooled to enlarge sample sizes for subsequent analysis. Grizzly bear use of the 5 DRCs was significantly different from expected based on availability ($X^2 = 132.51$, 4 df, $P < 0.001$). Grizzly bears used DRCs 1 and 2 less than expected ($P < 0.05$) and used DRCs 4 and 5 more than expected (Table 1). Use of DRC 3 was not different from expected. Grizzly bear use of DRCs 1 and 2 combined was 20% of expected.

Individual Variation. — Of the 3 grizzly bears in the sample, all used DRCs 1 and 2 less than expected and all used DRC 3 as expected. Individual variation occurred in the most distant DRCs. One individual used DRC 4 more than expected and the other 2 used it as expected. Two individuals used DRC 5 more than expected and 1 individual used it as expected.

Variation by Sex. — Comparisons of male and female use of the 5 DRCs indicated similar patterns except in DRC 4. Both sexes used DRCs 1 and 2 less than expected, DRC 3 as expected, and DRC 5 more than expected. Female use of DRC 4 was greater than expected and male use was not different from expected.

Influence of Habitat. — Our analysis of how roads affected grizzly bear distribution indicated avoidance of DRCs 1 and 2. Use of a specific habitat should have declined relative to the availability of that habitat in DRCs 1 and 2, if bears were responding to the road. To examine this effect, we compared the use of each habitat component with expected use in each DRC.

Table 1. Proportional use (U) and availability (A) of distance to road categories (DRC) for grizzly bears and black bears in the Cabinet Mountains, 1983-1988.

Species / Season	*n*	DRC 1 0-274 m U	P^a	A	DRC 2 275-914 m U	*P*	A	DRC 3 915-1,859 m U	*P*	A	DRC 4 1,860-3,322 m U	*P*	A	DRC 5 >3,322 m U	*P*	A
Grizzly bear																
Annual	233	0.009	<	0.205	0.073	<	0.201	0.202	=	0.198	0.296	>	0.198	0.421	>	0.198
Black bear																
Spring	646	0.158	<	0.205	0.180	=	0.201	0.303	>	0.198	0.274	>	0.198	0.085	<	0.198
Fall	573	0.082	<	0.205	0.143	<	0.201	0.290	>	0.198	0.291	>	0.198	0.194	=	0.198

[a] Significant differences ($P < 0.05$) indicated by sign: < less than, > greater than, = no difference.

Of the 10 habitat components with grizzly bear locations, sample sizes of use and availability were adequate only for timber, shrubfield snowchute, and graminoid park habitat components. These 3 habitat components accounted for 68% of use and provided a range of cover and food values. Use of timber was less than expected in DRCs 1 and 2. Use of shrubfield snowchutes was less than expected in DRC 1 and, as expected, in DRC 2. Graminoid park habitat in DRCs 1 and 2 was used less than expected. These results appear largely consistent with the hypothesis that grizzly bear avoidance of DRCs 1 and 2 was not related to habitat availability.

Trail Influences on Grizzly Bears

Grizzly bear radio locations in the 0-914 m zone of influence from roads (DRCs 1 and 2) were removed from the analysis of the influence of trails. Of the 283 remaining grizzly bear locations, 215 were from the air and 68 were from the ground. A significant difference was detected in grizzly bear use of the 5 DTCs between aerial and ground locations (X^2 = 12.89, 1 df, P = 0.012). Ground locations were usually obtained when animals were closer to trails and were omitted from further analysis.

Seasonal Variation. — Spring (n = 124) and fall (n = 91) use of the 5 DTCs was not significantly different (X^2 = 8.36, 1 df, P = 0.079). Therefore spring and fall locations were pooled to enlarge sample sizes for subsequent analysis. Grizzly bear use of the 5 DTCs was significantly different from expected based on availability (X^2 = 70.56, 4 df, P < 0.001). Grizzly bears used DTCs 1 and 3 less than expected and used DTC 5 more than expected (Table 2). All other DTCs received use as expected. Grizzly bear use of DTC 1 was 42% of expected.

Individual Variation. — All 3 grizzly bears used DTC 1 less than expected and all used DTCs 2, 3, and 4 as expected. Individual variation occurred in the most distant DTC. One individual used DTC 5 more than expected and the other 2 used it as expected.

Variation by Sex — Comparisons of male and female use of the 5 DTCs indicated identical patterns. Both sexes used DTC 1 less than expected and DTC 5 more than expected. The remaining DTCs were used as expected.

Influence of Habitat. — Our analysis of trail influences on grizzly bear distribution indicated avoidance of DTC 1. Use of a specific habitat should have declined relative to availability in DTC 1, if bears were responding to the trail. Again we compared the use of each habitat component with expected use in each DTC.

Grizzly bear use of timber, shrubfield snowchute, and graminoid park habitat components were examined in the same manner as the road influence analysis. Use of timber was less than expected in DTC 1. Shrubfield snowchute and graminoid park habitats in DTC 1 were used as expected. These results appear to indicate that grizzly bear avoidance of habitat in DTC 1 was at least partially related to habitat availability.

Road Influences on Black Bears

Of the 1,674 black bear locations, 1,219 were from the air and 455 were from the ground. A significant difference was detected in black bear use of the 5 DRCs between aerial and ground locations (X^2 = 177.23, 1 df, P < 0.001). As with grizzly bear data, ground locations were usually obtained when animals were closer to roads and were omitted from further analysis.

Seasonal Variation. — Spring (n = 646) and fall (n = 573) use of the 5 DRCs was compared to availability. Black bear use of the 5 DRCs was significantly different from expected during spring (X^2 = 105.12, 4 df, P < 0.001) and fall (X^2 = 101.49, 4 df, P < 0.001). Seasonal variation was most apparent in DRCs 2 and 5. Black bears used DRCs 1 and 5 less than expected and used DRCs 3 and 4 more than expected during spring (Table 1). Use of DRC 2 was not different from expected.

Table 2. Proportional use (U) and availability (A) of distance to trail categories (DTC) for grizzly bears and black bears in the Cabinet Mountains, 1983-1988.

Species / Season	n	DTC 1 0-122 m U	P^a	A	DTC 2 123-305 m U	P	A	DTC 3 306-610 m U	P	A	DTC 4 611-1,128 m U	P	A	DTC 5 >1,128 m U	P	A
Grizzly bear																
Annual	215	0.098	<	0.234	0.172	=	0.166	0.144	<	0.213	0.177	=	0.189	0.409	>	0.198
Black bear																
Spring	544	0.145	<	0.234	0.237	>	0.166	0.261	=	0.213	0.241	>	0.189	0.116	<	0.198
Fall	526	0.068	<	0.234	0.127	<	0.166	0.274	>	0.213	0.276	>	0.189	0.255	>	0.198

[a] Significant differences ($P < 0.05$) indicated by sign: < less than, > greater than, = no difference.

During fall, DRCs 1 and 2 were used less than expected and DRCs 3 and 4 were used more than expected. Use of DRC 5 was not different from expected. Black bear use of DRC 1 was 67% of expected during spring. Use of DRCs 1 and 2 was 55% of expected during fall.

Individual Variation. — Twenty-three black bears provided adequate sample sizes to analyze variation. Fourteen bears used the closest DRC less than expected and 2 used it more than expected. Nine individuals used DRC 2 less than expected. Two bears used DRC 3 less than expected and 4 used it more than expected. Four bears used DRC 4 less than expected and 7 used it more than expected. The most distant DRC received less than expected use from 8 bears and 1 bear used it more than expected. Other individual use was not different from expected.

Variation by Sex. — Variation between male and female black bear use of the 5 DRCs was apparent. Male black bear use of each of the 5 DRCs was not different from expected. Female black bear use of DRCs 1, 2, and 5 was less than expected. Female use of DRCs 3 and 4 was greater than expected.

Variation by Female Reproductive Status. — Black bear females with cubs were compared to the same females during years when they were alone or were accompanied by yearlings for a portion of the year ($n = 8$). Use patterns of females with cubs and females without cubs were identical in the 3 closest DRCs. Variation occurred in the 2 most distant DRCs. Both reproductive categories used DRC 1 less than expected, used DRC 2 as expected, and used DRC 3 more than expected. Females with cubs used DRC 4 as expected and used DRC 5 less than expected. Females without cubs used DRC 4 more than expected and used DRC 5 as expected.

Influence of Habitat. — Our analysis of how roads affected black bear distribution indicated avoidance of DRC 1 in spring and DRCs 1 and 2 in fall. Use of a specific habitat should have declined relative to availability in DRCs 1 and 2 if bears were responding to the road. To examine this effect we compared the use of each habitat component with expected use in each DRC.

Of the 12 habitat components with black bear locations, sample sizes of use and availability were adequate only for timber, shrubfield snowchute, shrubfield burn, and graminoid park components. These 4 habitat components accounted for 79% of use and provided a range of cover and food values. Use of timber was less than expected in DRC 1 during spring and fall. Fall use of timber in DRC 2 was not different from expected. Use of shrubfield snowchutes in DRCs 1 and 2 was not different from expected during both seasons. Spring and fall use of shrubfield burn habitat was less than expected in DRC 1 and as expected in DRC 2. Graminoid park habitat in DRCs 1 and 2 received use as expected during both seasons. Black bear avoidance of habitat in DRC 1 appeared partially related to habitat availability during spring and fall. Fall avoidance of DRC 2 appeared largely related to habitat availability.

Trail Influences on Black Bears

Black bear radio locations in the 0-274 m zone of influence from roads (DRC 1) were removed from the analysis of the influence of trails. Of the 1,376 remaining black bear locations, 1,070 were from the air and 306 were from the ground. A significant difference was detected in bear use of the 5 DTCs between aerial and ground locations ($X^2 = 91.83$, 1 df, $P < 0.000$). As with grizzly bear data, ground locations were usually obtained when animals were closer to trails and were omitted from further analysis.

Seasonal Variation. — Spring ($n = 544$) and fall ($n = 526$) use of the 5 DTCs was compared to availability. Black bear use of the 5 DTCs was significantly different from expected during spring ($X^2 = 50.13$, 4 df, $P < 0.001$) and fall ($X^2 = 107.02$, 4 df, $P < 0.001$). Seasonal variation was most apparent in DTCs 2, 3, and 5. Black bears used DTCs 1 and 5 less than expected and used DTCs 2 and 4 more than expected during spring (Table 2). Spring use of DTC 3 was not different from expected. During fall, DTCs 1 and 2 were used less than expected and DTCs 3, 4, and 5 were used more than expected. Black bear use of DTC 1 was 62% of expected during spring. Use of DTCs 1 and 2 was 49% of expected during fall.

Individual Variation. — Twenty-three black bears provided adequate sample sizes to analyze individual variation. The closest DTC received less than expected use from 14 bears. Two individuals used DTC 2 less than expected and 1 individual used it more than expected. Two bears used DTC 3 more than expected. One bear used DTC 4 less than expected and 4 bears used it more than expected. The most distant DTC received less than expected use from 6 bears and 2 bears used it more than expected. Other individual use was not different from expected.

Variation by Sex. — Variation between male and female black bear use was apparent in the 3 most distant DTCs. Male and female black bears used DTC 1 less than expected and used DTC 2 as expected. Male black bear use of DTCs 3, 4, and 5 was not different from expected. Female black bears used DTCs 3 and 4 more than expected and used DTC 5 less than expected.

Variation by Female Reproductive Status. — Black bear females with cubs were compared to the same females during years when they were alone or were accompanied by yearlings for a portion of the year ($n = 8$). Use patterns of females with cubs and females without cubs were identical in all but the 2 most distant DTCs. Both reproductive categories used DTC 1 less than expected and used DTCs 2 and 3 as expected. Females with cubs used DTC 4 more than expected and used DTC 5 less than expected. Females without cubs used DTCs 4 and 5 as expected.

Influence of Habitat. — Our analysis of trail influence on black bear distribution indicated avoidance of DTC 1 in spring and DTCs 1 and 2 in fall. Use of a specific habitat should have declined relative to availability in those DTCs if bears were responding to the trail. Again we compared the use of each habitat component with expected use in each DTC.

Black bear use of timber, shrubfield snowchute, shrubfield burn, and graminoid park components were examined in the same manner as the road influence analysis. Use of shrubfield snowchutes and shrubfield burns was less than expected in DTC 1 during spring. Spring use of timber and graminoid parks in DTC 1 was not different from expected. Fall use of all 4 habitat components was less than expected in DTC 1 and as expected in DTC 2. Black bear avoidance of DTC 1 appeared partially related to habitat availability during spring, however fall avoidance of DTC 1 did not appear related to habitat availability. Fall avoidance of DTC 2 appeared related to habitat availability.

Influences of Seasonal Road Closures

We used radio location data from the Bear Creek drainage to further examine the relationship between roads and bear distributions. Bear Creek had a 4-km segment of road that was opened to vehicles from 1 July to 15 October. The drainage was steep-sided and approximately 2.5-km wide over the 6.5-km length upstream from the road gate. Traffic generally consisted of passenger cars and pickup trucks. Average vehicle passes were 9.3 per day or 4.6 round trips per day during 1987. We compared distances from radio locations to the road when it was open to vehicles and when it was closed.

A comparison of air and ground grizzly bear locations in the Bear Creek drainage did not indicate a significant difference and therefore samples were pooled ($t = 1.88$, 42 df, $P = 0.067$). Mean distance from grizzly bear radio locations to the road increased from 655 m ($n = 23$) before the opening on 1 July to 1,122 m ($n = 21$) after opening ($t = -3.77$, 42 df, $P < 0.001$). Arguments could be made that bears were following plant phenology to higher elevations after 1 July and would therefore be further from the road. Mean elevation of grizzly bear radio locations increased from 1,375 m before 1 July to 1,482 m after 1 July, but the difference was not significant ($t = -1.87$, 42 df, $P = 0.068$). Moreover, the mean elevation increase of 107 m did not appear to be sufficient to account for the 467 m increase in distance to the road in such a steep, narrow drainage.

Comparisons of air and ground black bear locations did indicate a significant difference and therefore ground locations were omitted from further analysis ($t = 3.87$, 113 df, $P < 0.001$). Mean distance from black bear radio locations to the road increased from 764 m ($n = 19$) before the road opened on 1 July to 927 m ($n = 25$) after 1 July, but the difference was not significant ($t = -1.00$, 42 df, $P = 0.324$).

Influence of the Time of Locations

All locations used in this analysis were obtained during daylight hours. Nocturnal use of habitat near open roads and trails would not have been detected. Twenty-four hour monitoring was conducted to determine the activity patterns of grizzly bears. Of 14 24-hour monitoring sessions, 8 recorded activity largely during the daylight hours, 3 recorded activity largely during the early morning and late evening hours, and 3 recorded activity largely at night. These data appeared to indicate that most grizzly bear activity occurred during the daylight hours and was sampled by our radio locations.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Habitat security is an important aspect of both grizzly bear and black bear habitat management. Results of this study indicated that grizzly bears avoided habitat within 914 m (DRCs 1 and 2) of open roads and black bears avoided habitat within 274 m (DRC 1) of open roads. Though grizzly bear sample sizes were small, this study provided data from a very low density population where sample sizes were unlikely to be large. Studies from other grizzly bear populations at higher densities have also found avoidance of roads. Research in southeastern British Columbia, found that grizzly bears used the area within 100 m of roads less than expected on the basis of availability (McLellan and Shackleton 1988). A 58% loss of habitat was observed within this zone. Archibald et al. (1987) reported that female grizzly bear use of habitat within 150 m of roads declined 78% during log hauling activities associated with timber harvest in a coastal British Columbia forest. Mattson et al. (1987) found that grizzly bears in Yellowstone National Park tended to avoid habitat within 500 m of roads during spring and summer and tended to avoid habitat within 3 km of roads during fall. Black bear research on the effects of oil development complexes noted little response from bears within 2 km of activity sites (Tietje and Ruff 1983). In northern Idaho, Young and Beecham (1986) found that female black bears avoided roadsides and male black bears used roadsides in proportion to availability.

Trails (including closed roads) displaced both species of bears less than open roads. This information supports the value of the road closure system for bear habitat management. Mitigation for mineral and timber extraction in grizzly bear habitat should utilize road closures during and after the project to control the volume of activity.

Road and trail avoidance zones from this study represent the best data currently available from this ecosystem. This information should be used in the development of habitat effectiveness coefficients for the grizzly bear cumulative effects model.

Twenty-eight percent of all grizzly bear locations occurred in the 3 closest DRCs (60% of the area). Grizzly bear avoidance of high quality habitat near roads and trails may lessen the opportunity for individuals to obtain food and increase intraspecific competition by further forcing bears into limited remote habitat. Conversely, 58% of black bear locations occurred in the 3 closest DRCs. Black bear tolerance of disturbance may provide an opportunity for this species to exploit habitat in DRCs 1-3 in the relative absence of grizzly bears.

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