

Grizzly bear selection of managed and unmanaged forests in the Selkirk Mountains

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Abstract: We tested the commonly held hypotheses that grizzly bears (*Ursus arctos*) select against clearcuts and young forests and select for natural openings and old forests in the Selkirk Mountains from 1986 to 1991. We compared use versus availability using χ^2 goodness-of-fit for 11 bears (five females, six males) in a south study area containing both open roads (public use allowed) and closed roads (no public use allowed) and 11 bears (seven females, four males) in a north study area containing restricted roads (forestry use only). Zero of 11 females and 1 of 11 males (1/22 bears) selected against ($P < 0.05$) clearcuts. Five of 11 females and 2 of 11 males (7/22 bears) selected against ($P < 0.05$) young forests. The apparent selection against young forests appeared to be due to selection against associated open roads, not against young forests themselves. Forestry activities alone (managed forests and restricted roads) appeared to have no negative impact on grizzly bear habitat use. Because of small sample sizes, pooling of seasonal data, and lack of experimental replication, our results should not be extrapolated until similar studies are conducted elsewhere.

Résumé : Nous avons testé les hypothèses courantes voulant que les ours grizzly (*Ursus arctos*) évitent les coupes à blanc et les jeunes forêts et sélectionnent les ouvertures naturelles et les vieilles forêts dans les Monts Selkirk, de 1986 à 1991. Nous avons comparé l'utilisation vs la disponibilité en utilisant le test d'ajustement du χ^2 pour 11 ours (cinq femelles et six mâles) dans une aire d'étude du sud contenant des chemins ouverts (au public) et des chemins fermés (au public) et 11 ours (sept femelles et quatre mâles) dans une aire d'étude du nord contenant des chemins à accès restreint (limités aux forestiers). Aucune des 11 femelles et 1 des 11 mâles (1/22 ours) ont évité ($P < 0,05$) les coupes à blanc. Cinq des 11 femelles et 2 des 11 mâles (7/22 ours) ont évité ($P < 0,05$) les jeunes forêts. L'évitement apparent des jeunes forêts semblait dû à un évitement des chemins ouverts plutôt que des forêts elles-mêmes. Les activités forestières (forêts aménagées et chemins à accès restreint) ne semblent pas avoir d'impact négatif sur l'utilisation de l'habitat par l'ours grizzly. En raison de la faible taille de l'échantillon, du regroupement des données de différentes saisons et de l'absence de répétition expérimentale, nos résultats ne devraient pas être extrapolés tant que d'autres études semblables n'auront pas été menées ailleurs.

[Traduit par la Rédaction]

Introduction

The Selkirk Mountains Grizzly Bear Ecosystem (SMGBE) includes parts of southeastern British Columbia, northern Idaho, and northeastern Washington. Grizzly bears within the U.S. SMGBE are classified as threatened by the U.S. Fish and Wildlife Service (Servheen 1990). Bears within the British Columbia portion are classified as vulnerable by the Committee on the Status of Endangered Wildlife in Canada (Banci 1991) and threatened by the grizzly bear conservation strategy of British Columbia (B.C. Ministry of Environment 1995a, 1995b; Wielgus 2002). Forestry is the major anthropogenic activity in this area. Wielgus et al. (1994, 2001) and Wielgus and Bunnell (1995, 2000) studied population dy-

namics and landscape-level habitat use of grizzly bears in the SMGBE from 1985 through 1991 and found that population growth was marginal and appeared to be limited by human-caused mortalities near open forestry roads.

Habitat losses from clearcuts and young second-growth forests are also believed to cause negative impacts (B.C. Ministry of Environment 1995a, 1995b). The popular assumption is that bears avoid managed forests (clearcuts and young second-growth forests) because of forestry-related human disturbance and a relative paucity of foods in dense, young forests. This is presumed to result in habitat loss and reduced fitness attributes such as reproductive success.

Zager et al. (1983) found that grizzly bears appeared to use clearcuts little despite abundant food, probably because of security concerns associated with human access. McLellan and Hovey (2001) also found that regenerating clearcuts were ranked among the least favored habitats. They suggested that food was poor in their clearcuts. McLellan (1990) also mentioned that young second-growth stands might not be used because of poor food. However, the studies that examined the effects of forestry on grizzly bears (Zager et al. 1983; Archibald et al. 1987; McLellan and Shackleton 1988, 1989a, 1989b; Kasworm and Manley 1990; Mace et al. 1996, 1999; McLellan and Hovey 2001) all took place in open road areas and therefore also incorporated the effects

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of open roads, not the effects of managed and unmanaged forests alone. The observed avoidance of clearcuts and second-growth forests could be due to avoidance of associated open roads and not avoidance of the clearcuts or young forests themselves. If so, restrictions on human access to forestry roads could ameliorate any habitat losses.

In a previous paper, Wielgus et al. (1994) reported that all known human-caused mortalities in the SMGBE occurred in their south study area and were associated with open roads. No known mortalities occurred in their north study area where roads were restricted to forestry use only. In a more recent study, Wielgus et al. (2002) reported on effects of open, closed, and restricted forestry roads on grizzly bear habitat use. Bears selected against open roads (all human activities allowed) and intermixed, associated closed roads (no human access allowed) in their south study area but not against restricted roads (only forestry activities allowed) in their north study area. In this paper, we compare selection of managed and unmanaged forests in the open and restricted road areas and separate the effects of selection against open roads from selection against managed (clearcuts, second growth) forests. The presence of restricted roads in this study area provides a unique opportunity to examine the effects of forestry use alone. There was no sexual segregation or displacement of females by males in this study area (Wielgus and Bunnell 1995), so use of managed and unmanaged forests should be unaffected by these intra-specific social factors.

Study area

The SMGBE covers approximately 5700 km², with 3000 km² in northern Idaho and northeastern Washington and 2700 km² in southeastern British Columbia (48–49°N, 116–117°W). We split the SMGBE into a 1420-km² south study area (south of B.C. highway No. 3) and a 1994-km² north study area because of different road types and because bears were captured in and tended to restrict their activities to one or the other area (Wielgus et al. 1994, 2002; Wielgus and Bunnell 1995). The south study area contained intermixed open (all traffic allowed, high traffic volume) and closed (no traffic allowed, low traffic volume) roads, and the north study area contained restricted (forestry traffic only allowed, moderate traffic volume) roads (Wielgus et al. 2002). Road densities were similar (0.5 versus 0.4 km/km²) in preferred ESSF (see next paragraph) habitats for south and north study areas. Grizzly bears avoided open and intermixed closed roads but did not avoid restricted roads (Wielgus et al. 2002).

Physiography of the SMGBE was mountainous and climate was Pacific maritime – Continental. Vegetation was classified into the Engelmann Spruce – Subalpine Fir (ESSF) (*Picea engelmannii* – *Abies lasiocarpa*), Interior Cedar – Hemlock (ICH) (*Thuja plicata* – *Tsuga heterophylla*), and Alpine Tundra (AT) biogeoclimatic zones (Pojar et al. 1987; Wielgus et al. 2002). The southern study area was composed of 60% ICH, 37% ESSF, and 3% AT. The northern study area was composed of 40% ICH, 45% ESSF, and 15% AT. Grizzly bears selected for the ESSF and against the ICH in both study areas (Wielgus et al. 2002).

Clearcuts composed approximately 8%, natural openings 15%, young forests 20%, and old forests 55% of the available habitat (see Tables 1 and 2). Average size of clearcuts was 1.66 km² and average size of natural openings was 96 km² (e.g., large burns). Riparian areas were not classified separately in this analysis. For a more detailed description of the study area, see Wielgus and Bunnell (1995, 2000) and Wielgus et al. (2002).

Materials and methods

Trapping and monitoring

We trapped and radiocollared grizzly bears in two areas. The Idaho trapping zone in the south encompassed 100 km² in northern Idaho and covered a 20-year-old burn dominated by huckleberry (*Vaccinium* spp.) shrubfields. The B.C. trapping zone covered 235 km² and was located about 20 km north of the Idaho trapping zone. We trapped in Idaho 1 May – 30 June from 1985 to 1987 and 8–25 August in 1989. Trapping in British Columbia occurred from 25 May to 26 July during 1988–1989.

We trapped bears using Aldrich leg snares and immobilized them with 4.5 mg of Ketamine hydrochloride and 2.3 mg of Xylazine hydrochloride per kilogram of body mass. We sexed, weighed, lip-tattooed, ear-tagged, and extracted a premolar tooth for aging (Stoneburg and Jonkel 1966). We fitted all bears with mortality-sensing “drop-off” (Hellgren et al. 1988) radiocollars (Telonics, Mesa, Ariz.). We determined sex during capture and estimated age from known birthdate or by counting cementum annuli. We handled bears according to the protocols of the Canadian Council on Animal Care, University of British Columbia animal care certificate 890105. For further details on trapping, see Wielgus et al. (1994) and Wielgus and Bunnell (1995, 2000).

We conducted aerial radiotelemetry of collared bears from fixed-wing aircraft (Whitehouse and Steven 1977) at weekly intervals to ensure independence of location data (White and Garrott 1990; Swihart and Slade 1997; Allredge et al. 1998). Flights were conducted from early April to early November from 1986 to 1991 to monitor the location of the bears. Flights were conducted from 06:00 to 12:00, so interpretation of habitat use is restricted to daytime only. Locations of bears were plotted on 1 : 24 000 (United States) or 1 : 50 000 (Canada) topographic maps and by taking aerial Polaroid photographs of the bears' location from the aircraft. Topographic and photographic locations were later transferred to 1 : 20 000 forest cover maps. Accuracy of locations was determined by placing test collars in known locations, by visual confirmations of bears from the air, and by ground searching for fresh bear signs (scats, tracks, digs, hairs) at the estimated location within 1 week of the flight.

Habitat classification

Both the south and north study areas were mapped at 1 : 20 000 scale for forest cover types and roads by forest management agencies (B.C. Ministry of Forests, Darkwoods Forestry, Idaho Department of Lands, U.S. Forest Service). Agency maps were constructed from aerial photographs and fieldwork conducted from 1985 to 1990. We updated older data (1985–1988) by interviewing area foresters for recent

changes and by conducting field checks from 1989 to 1991. We then merged and digitized the various maps using ArcInfo/Arcview into a single geographic information system (GIS) coverage. Forest cover polygons smaller than 1 ha were not mapped by agencies and were incorporated into surrounding polygons larger than 1 ha; therefore, small openings <1 ha in forest or small forest patches <1 ha in openings were not analyzed for habitat use.

To test the hypothesis that grizzly bears selected against clearcuts but not natural openings, we classified all cutting units <20 years old as clearcuts and all other early seral vegetation types (e.g., burns, brushfields, meadows, avalanche chutes, etc.) as natural openings. We classified all forests >20 years old as forest. To separate selection against open roads from selection against forest types, we compared selection of forest types between the south (where bears selected against open roads) and north (where bears did not select against restricted roads) study areas (Wielgus et al. 2002). To provide a fair comparison for selection of clearcuts and natural openings, we excluded any habitat types and radiolocations from within the AT zone, since selection of natural openings in the AT (rock and ice) was not ecologically comparable with selection of anthropogenic openings (clearcuts) in the lower elevation ICH and ESSF forests. This resulted in smaller sample sizes than those obtained for young versus old forests (see below).

To test the hypothesis that grizzly bears selected against young second-growth forest but not uncut old forests, we classified all forests >20 years but <70 years old as young forest and all forests >70 years old as old forest because the rotation age in this area was approximately 70 years (Darkwoods Forestry, personal communication). We classified all cutting units <20 years old and all natural openings as shrubfield and all other types (including AT) as nonforest. To separate selection against open roads from selection against young forests, we compared use of young forests within the south (open roads) and north (restricted roads) study areas.

Bear selection of forest types

We analyzed use of forest types for 22 independent grizzly bears (five females and six males in the south and seven females and four males in the north) from 1986 to 1991. We tested for selection of forest types by comparing observed and expected numbers of radiolocations for different forest types for each individual bear (White and Garrott 1990). We did not pool data among bears because of high potential bias and (or) type 2 errors associated with variability in sample size and behavior among bears (White and Garrott 1990, pp. 188–191; Swihart and Slade 1997; Allredge et al. 1998). We pooled location data among years for each bear because of small annual sample sizes for each bear (McLellan and Hovey 2001). Unlike McLellan and Hovey (2001), we did not analyze seasonal effects and reproductive status on use of forest types because our sample sizes were too small to allow such tests. We did not pool seasonal or reproductive samples among bears to increase sample size for the same reasons that we did not pool locations among bears (increased bias and type 2 errors).

We used three categories (clearcut, opening, forest) to test the first hypothesis (bears select against clearcuts but not

openings) and four categories (shrubfield, young forest, old forest, nonforest) to test the second hypothesis (bears select against young forests but not old forests). This four-category maximum allowed adequate sample sizes for testing (e.g., mean expected values >2, Roscoe and Byers 1971; <20% of cells with expected values <5, Allredge and Ratti 1986; Wilkinson et al. 1992).

We tested for both type 2 (selection of home range) and type 3 (selection within home range) selection (Johnson 1980; Thomas and Taylor 1990) because selection can occur at either or both levels (White and Garrott 1990). Expected values for type 2 selection were calculated from the percentage of the south or north study area that covered each forest type multiplied by the number of radiolocations for each bear. The south and north study areas corresponded to the multiannual, convex polygon, composite home ranges of southern and northern bears (Wielgus et al. 2002). We used radiolocations and not the proportion of the home range in each forest type for observed values to allow consistency and comparability with our type 3 analyses and because the proportional method assumes uniform use of the home range (White and Garrott 1990, p. 201), which was disproved by our type 3 analyses (see Results). Expected values for southern males were calculated from the percentage of both the south and north study areas that covered each forest type because southern males traveled throughout the entire study area (Wielgus et al. 2002). Expected values for northern males and all females were calculated from the south or north study area because these bears restricted themselves to those areas (Wielgus et al. 2002). Expected values for type 3 selection were calculated from the percentage of a bear's 100% minimum area home range (Ackerman et al. 1990) covered by the different forest types multiplied by the number of radiolocations for each bear.

Radiolocation points inside the AT zone and in unclassified forest types (e.g., private lands in Idaho, unknown types in British Columbia) were not used in calculating observed or expected values. We used χ^2 goodness-of-fit (Daniel 1978) followed by Bonferroni's z test (Neu et al. 1974) to test for selection. Statistical significance was reported if the two methods yielded consistent results (Cherry 1996). Statistical significance was set at $P < 0.05$. Empty cells were eliminated by adding a delta value of 0.5 to those cells (Wilkinson et al. 1992). Effects of managed and unmanaged forests were presented as mean use/availability or selection ratios (Manly et al. 1993, pp. 9–11) for statistically significant test results.

Results

Aerial telemetry accuracy averaged approximately ± 100 m based on radiobeacons, visual confirmations, and the presence of bear signs at the estimated radiolocation site during followup site investigations. Seventeen percent of radiolocations were visually confirmed from the air and 72% of site investigations ($n = 311$) had fresh grizzly bear signs (tracks, scats, digs, hairs) within 100 m of the estimated telemetry location.

Bears were monitored for an average of 3.13 years (SD = 0.99, $n = 22$), with variation depending on date of capture and date of death or radio failure. Each male was monitored

Table 1. Observed and expected (type 2 and type 3) number of locations for grizzly bears in clearcuts, natural openings, and forests in the Selkirk Mountains Grizzly Bear Ecosystem.

Bear No.	<i>n</i>	Type 2 observed/expected locations			Type 3 observed/expected locations		
		Clearcut	Opening	Forest	Clearcut	Opening	Forest
South area							
Females							
867	89	3/6	47/13*	39/70*	3/4	47/27*	39/58*
1015	40	2/3	13/6*	25/31*	2/4	13/9	25/27
1084	49	1/3	20/7*	29/39*	1/3	20/12*	29/35
1087	60	2/4	23/9*	35/47*	2/5	23/10*	35/45*
1089	16	1/1	9/2*	6/12*	1/1	9/5	6/10
Males							
962	34	1/2	20/5*	13/27*	1/1	20/10*	13/23*
1004	42	1/3	22/6*	19/33*	1/4*	22/10*	19/28*
1005	23	2/2	6/3	15/18	2/3	6/4	15/15
1077	20	1/2	10/3*	9/15*	1/2	10/3*	9/14*
1090	36	6/2	5/5	25/28	6/4	5/4	25/28
1091	23	3/2	5/3	15/18	3/3	5/5	15/15
North area							
Females							
1044	18	2/1	5/3	11/14	2/2	5/2*	11/14
1045	40	10/3*	8/6	22/32*	10/6	8/4	22/30*
1047	17	2/1	6/2	9/13	2/2	6/3	9/11
1048	54	7/3	22/8*	25/43*	7/7	22/13*	25/34*
1056	51	5/3	6/7	40/40	5/5	6/4	40/41
1075	42	3/3	21/6*	18/33*	3/4	21/11*	18/27*
1076	36	8/2*	5/5	23/28*	8/6	5/3	23/27
Males							
1043	42	6/3	6/6	30/33	6/6	6/5	30/32
1046	45	4/3	10/7	31/36	4/5	10/5	31/36
1057	42	6/3	10/6	26/33*	6/6	10/5	26/31
1078	41	1/3	8/6	32/32	1/4	8/8	32/29

Note: Type 2 expected values based on percent composition of south and north study areas for females and northern males and percent composition of entire study area for southern males; type 3 expected values based on percent composition of home range.

*Observed number of locations is less than or greater than expected at $P < 0.05$ ($\chi^2 = 5.99$, 2 df) using χ^2 goodness-of-fit followed by Bonferroni z tests.

for at least 2 years and 9/12 females for at least 3 years (three females at 2 years each) to ensure variation in years and reproductive status for each bear. Sample sizes for individual bears are given in Tables 1 and 2. Radiolocations were relatively evenly distributed across years and months to ensure that these data sets were not biased towards particular years or months. There was a mean of 265 (SD = 114) radiolocations/year for 1986–1990 and a mean of 166 (SD = 64) radiolocations/month for April–November. We obtained a total of 843 useable radiolocations for analysis of clearcuts versus openings (excludes AT locations) and 1007 useable locations (includes AT locations) for analysis of young versus old forests.

Clearcuts versus natural openings

In the south, zero of five females selected ($P < 0.05$) against clearcuts and five of five females selected for natural openings (Table 1). Mean selection ratios for clearcuts and openings were 0.60 (SE = 0.11, $n = 5$) and 3.10 (SE = 0.41, $n = 5$). One of six males selected against clearcuts and three

of six selected for openings. Mean selection ratios were 0.82 (SE = 0.18, $n = 6$) and 1.88 (SE = 0.34, $n = 6$). Combining sexes, one of 11 bears selected against clearcuts and eight of 11 selected for natural openings. Natural openings were selected for approximately four times that of clearcuts in the south.

In the north, two of seven females selected ($P < 0.05$) for clearcuts and three of seven selected for openings. Selection ratios were 2.33 (SE = 0.39, $n = 7$) and 2.18 (SE = 0.33, $n = 7$). No males selected against clearcuts or selected for openings, but selection ratios were similar for both (1.41 versus 1.36). Combining sexes, two of 11 bears selected for clearcuts and three of 11 selected for openings. Selection ratios were similar at about 2 for both clearcuts and openings in the north.

Summarizing over both areas, only one of 22 bears selected against clearcuts, two of 22 selected for clearcuts, and half selected for natural openings (11/22). Regarding our initial hypotheses, bears did not select against clearcuts but they did select for natural openings.

Table 2. Observed and expected (type 2 and type 3) number of locations for grizzly bears in shrubfields, young forests, old forests, and nonforests in the Selkirk Mountains Grizzly Bear Ecosystem.

Bear No.	<i>n</i>	Observed/expected locations							
		Shrubfield		Young forest		Old forest		Nonforest	
		Type 2	Type 3	Type 2	Type 3	Type 2	Type 3	Type 2	Type 3
South area									
Females									
867	92	35/9*	35/21*	7/20*	7/6	35/52*	35/54*	15/11	15/12
1015	44	8/4	8/9	6/9	6/8	21/25	21/22	9/5	9/5
1084	54	11/6	11/9	5/12*	5/5	24/30	24/32*	14/7*	14/8
1087	60	23/6*	23/10*	3/13*	3/9*	32/34	32/36	2/7*	2/5
1089	15	8/2*	8/3*	0/3*	0/1	6/8	6/8	1/2	1/2
Males									
962	34	20/3*	20/7*	4/7	4/2	9/19*	9/21*	1/4*	1/4*
1004	46	13/3*	13/8	3/9*	3/6	18/27*	18/24	12/7	12/8
1005	29	4/2	4/4	3/6	3/5	15/17	15/14	7/4	7/6
1077	19	9/1*	9/3*	1/4*	1/4*	8/11	8/10	1/3*	1/3*
1090	39	6/3	6/4	10/8	10/10	16/23	16/19	7/6	7/5
1091	26	4/2	4/3	3/5	3/3	14/15	14/13	5/4	5/6
North area									
Females									
1044	24	2/1	2/2	9/4*	9/8	5/14*	5/8	8/4*	8/6
1045	56	12/5*	12/7	10/11	10/12	21/31*	21/29*	13/9	13/8
1047	30	2/2	2/3	4/6	4/3	16/18	16/16	8/5	8/8
1048	73	7/4	7/8	5/14*	5/10	32/43*	32/35	29/12*	29/21
1056	63	5/4	5/5	23/12*	23/14	26/37*	26/34	9/10	9/9
1075	50	3/3	3/4	5/9	5/4	19/29*	19/27*	23/8*	23/14*
1076	53	8/3	8/7	15/10	15/11	19/31*	19/27	11/9	11/8
Males									
1043	46	6/3	6/5	16/9*	16/10	17/27*	17/23	7/8	7/8
1046	50	6/3	6/8	8/9	8/13	28/29	28/26	8/8	8/7
1057	48	6/4	6/7	12/9	12/10	19/28	19/24	11/7	11/7
1078	56	1/3	1/5*	20/10*	20/8*	19/33*	19/29*	16/9	16/14

Note: Type 2 expected values based on percent composition of south and north study areas for females and northern males and percent composition of entire study area for southern males; type 3 expected values based on percent composition of home ranges.

*Observed number of locations is less than or greater than expected at $P < 0.05$ ($\chi^2 = 7.81$, 3 df) using χ^2 goodness-of-fit followed by Bonferroni z tests.

Young versus old forests

In the south, four of five females selected ($P < 0.05$) against young forests and two of five selected against old forests (Table 2). Selection ratios were 0.33 (SE = 0.10, $n = 5$) and 0.79 (SE = 0.05, $n = 5$). Two of six males selected against young forests and two of six selected against old forests. Selection ratios were 0.58 (SE = 0.15, $n = 6$) and 0.73 (SE = 0.07, $n = 6$). Most bears (three of five females and three of six males) selected for shrubfields. Selection ratios were 3.11 (SE = 0.49, $n = 5$) and 4.33 (SE = 1.20, $n = 6$) for shrubfields. Combining sexes, six of 11 bears selected against young forests, four of 11 selected against old forests, and six of 11 selected for shrubfields. Selection ratios were approximately 0.5 for young and old forests and 3.5 for shrubfields.

In the north, two of seven females selected ($P < 0.05$) for young forests and one of seven selected against young forests. Six of seven females selected against old forests. Selection ratios were 1.16 (SE = 0.28, $n = 7$) and 0.66 (SE = 0.06, $n = 7$) for young and old forests. Two of four males selected for young forests and two of four selected against old for-

ests. Selection ratios were 1.50 (SE = 0.25, $n = 4$) and 0.71 (SE = 0.09, $n = 4$) for young and old forests. Combining sexes, four of 11 bears selected for young forests, eight of 11 selected against old forests, and two of 11 selected for shrubfields. Selection ratios were approximately 1.35 for young forests and 0.65 for old forests.

Summarizing over both areas, seven of 22 bears selected against but four of 22 selected for young forests, 12 of 22 selected against old forests, and eight of 22 selected for shrubfields. Regarding our initial hypotheses, most females and some males in the south selected against young forests, but only one of 11 bears selected against young forests in the north. Most bears selected against old forests in both study areas.

Discussion

Our results do not support the hypothesis that grizzly bears select against clearcuts. Only one southern male bear (No. 1004) selected against clearcuts out of a total of 22

bears. Contrary to our expectations, grizzly bears did not select against clearcuts, even in the south study area where they selected against open and intermixed closed roads (Wielgus et al. 2002), which are presumably associated with clearcuts. Bears may not select against clearcuts, despite human disturbance (roads), because of abundant food in clearcuts (Zager et al. 1983). Our results are inconsistent with the findings of Zager et al. (1983) and McLellan and Hovey (2001) and the hypotheses proposed by the B.C. Ministry of Environment (1995a, 1995b) but are consistent with the findings of Servheen (1983) and Mace et al. (1996). They found that most grizzly bears were neutral or selected for clearcuts and that relatively few selected against clearcuts, even when these were associated with roads (Mace et al. 1996).

The lack of selection against clearcuts in our study area might also be attributed to low statistical power because of small sample sizes. However, examination of selection ratios suggests that only females in the south showed potential selection (0.60) against clearcuts; southern males (0.82), northern females (2.33), and northern males (1.41) would not select against clearcuts regardless of changes in sample size. When we arbitrarily quadrupled sample size for southern females, we did finally obtain statistically significant avoidance of clearcuts by southern females; however, we interpret that as avoidance of associated open roads and not the clearcuts themselves (see discussion on avoidance of second growth).

Clearcuts were not equivalent to natural openings in the south, since almost all bears selected for natural openings but not clearcuts. These results are consistent with the findings by Zager et al. (1983), Mace et al. (1996), and McLellan and Hovey (2001) whereby natural openings tend to contain more bear foods and (or) show less human intrusion than clearcuts. We believe that human intrusion may be more important here, since selection ratios were very similar between clearcuts and natural openings for both females (2.33 versus 2.18) and males (1.41 versus 1.36) in the restricted road area. Also consistent with Zager et al. (1983) and McLellan and Hovey (2001), grizzly bears selected against forests, probably because of the relative paucity of bear foods there. In terms of selection by bears, natural openings were selected for, clearcuts were neutral, and forests were selected against in our study area. Clearcuts had no discernable negative effect on habitat use by bears in the SMGBE.

Four of five female bears and two of six male bears selected against young forests in the south, but only one female selected against young forests in the north. Our results are inconsistent with the hypothesis that bears select against young forests because of the paucity of bear foods there. If this hypothesis were true, both females and males should have selected against young forests in both study areas. Our results are, however, consistent with the hypothesis that young forests are selected against because of increased human access (open roads) in managed forests. The same four females (Nos. 867, 1084, 1087, and 1089) and two of the same three males (Nos. 1004 and 1077) that selected against open roads in the south (Wielgus et al. 2002) selected against young forests in the south. The same is true for potential selection against clearcuts in the south. The only

bears that would have avoided clearcuts if sample sizes were quadrupled were those that avoided open roads.

Only one female selected against young forests in the north where roads were restricted to forestry use only. This suggests that selection against young forests (and potential selection against clearcuts) was related to selection against associated open roads and not scarcity of foods. This contrasts with our interpretation of neutral use of clearcuts in the south; however, relative abundance of food in the two forest types (clearcuts versus young forests) could explain the disparity. Since clearcuts tend to have an abundance of food relative to young forests, bears may take greater risks in using clearcuts. The higher selection ratios for clearcuts versus young forests (females = 0.60 versus 0.33, males = 0.82 versus 0.58) in the south suggest that this may be the case. Regardless of the exact reason why, it is clear that grizzly bears did not consistently select against young forests but mostly (6/7) selected against them when associated with open roads. Selection against old forests could be due to the relative paucity of foods there and (or) simply because of the very high percentage of old forests in the study area (McLellan 1986).

Management implications

Our results do not support the hypotheses that grizzly bears select against managed forests (clearcuts and young forests) and select for unmanaged forests (natural openings and old growth). Results of our previous work (Wielgus et al. 2002) also do not support the hypothesis that grizzly bears select against restricted (forestry only) roads but do support the hypothesis that grizzly bears select against open roads (and adjacent closed roads). Forestry activities by themselves (managed forests, restricted roads) had no discernable negative effect on grizzly bear habitat use, at least in the heavily forested SMGBE. The commonly accepted notion that bears and forestry activities are incompatible is not supported by our data. The only observed negative effects on habitat use (Wielgus et al. 2002; this paper) and population dynamics (Wielgus et al. 1994, 2001) were from open roads. We recommend that open forestry roads be restricted to forestry use only.

Our interpretations and recommendations require cautious caveats because of small sample sizes and lack of experimental replication and because we could not assess the potential effects of season and reproductive status on selection of forest types. Perhaps certain reproductive classes of females (e.g., with cubs) selected against managed forests during certain seasons (e.g., spring), but we could not test for such effects because of our small sample sizes. We realize that our results and conclusions are based on small sample sizes within a single geographical area and so encourage others to replicate our analyses elsewhere. We also realize that our results and conclusions will be extremely controversial; they should not be applied to ecosystems dissimilar from the SMGBE until such replications are conducted.

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