CANADIAN WILDLIFE BIOLOGY & MANAGEMENT

CWBM 2014: Volume 3, Number 2 ISSN: 1929–3100

Original Research

Grizzly Bear Behaviour in Forested, Clearcut and Non-Forested Areas in Sub-Boreal British Columbia

Lana M. CIARNIELLO[1], Douglas C. HEARD[2], and Dale R. SEIP[3]

[1] Aklak Wildlife Consulting, 3021 Jody Lynne Way, Campbell River, British Columbia, V9H 1N3, Canada. Email: aklak@telus.net

[2] British Columbia Ministry of Forests, Lands and Natural Resource Operations, 2000 South Ospika Boulevard, Prince George, British Columbia, V2N 4W5, Canada. Email: Doug.Heard@gov.bc.ca

[3] British Columbia Ministry of Environment, 1011 4th Avenue, Prince George, British Columbia, V2L 3H9, Canada. Email: dale.seip@gov.bc.ca

Abstract

Forestry operations impact the distribution, abundance and diversity of species as well as the processes of succession. To understand the mechanisms of how forestry affects Grizzly Bears (*Ursus arctos* L.), we need to know how bears use harvested stands and unlogged areas. To get at that, we visited 311 locations of 28 (16 female, 12 male) Grizzly Bears, 1998-2003, to determine how bears were using those sites. We determined the bears' primary activity at each site and categorized the cover type as either: (1) clearcut; (2) forested stand; or, (3) non-forested. Sites were normally visited within 7 days of the bear leaving the area. Grazing on graminoids and forbs was common in all three stand types. Bears fed on more ants/larvae in clearcuts than forested stands, whereas they fed on more meat in forested stands than clearcuts. We did not detect bears foraging more on berries in clearcuts than forested stands. Twenty percent of the identified behaviours related to non-foraging activities and resting was the primary non-foraging behaviour with bears resting more in forests than clearcuts or non-forested cover types. We also showed activity differences among spring, summer and fall. Moving/travelling occurred in all three cover types as expected, but bears travelled more in fall than spring or summer. Resting sites were more common in the forest than in the other landcover types in all three seasons. Overall, bears tended to feed in clearcuts and rest in forests.

Key Words: Bedding Sites, Behaviour, Clearcut, Food, Forestry, Grizzly Bear, Habitat Use, *Ursus arctos*.

Correspondence: Lana M. Ciarniello, Aklak Wildlife Consulting, 3021 Jody Lynne Way, Campbell River, British Columbia, V9H 1N3, Canada. Email: aklak@telus.net

INTRODUCTION

Forestry operations in central British Columbia (BC) are the dominant activity on the landscape and the *Forest and Range Practices Act* (FPPR 2010) states that the needs of Grizzly Bears (*Ursus arctos* L.) must be addressed during forest development activities. For Grizzly Bears, the concerns with forestry activities are primarily through the removal of canopy cover resulting in a reduction of security cover (Zager *et al.* 1983), the creation of monocultures and/or even age stands that may regenerate

with little forage for bears in the undergrowth (Elgmork 1978; McLellan 1990; McLellan and Hovey 2001), and the creation of roads to access blocks (Wielgus and Vernier 2003) that may lead to disturbance and an increase in human caused mortality. Conversely, forestry operations have been reported to increase early seral forage production for bears by removing the canopy and allowing increased light to penetrate the ground which in turn promotes the regeneration of certain early seral vegetation (Nielsen *et al.* 2004). The first three factors might adversely affect bears while increased forage productivity would likely be beneficial. Even though we know that Grizzly Bears can persist in logged landscapes (Nielsen 2011; Mowat *et al.* 2013), and Grizzly Bear habitat use and selection as it relates to forestry activities has been well documented (McLellan 1989, 1990; Nielsen *et al.* 2004; Ciarniello *et al.* 2007; Stewart *et al.* 2012), to understand the mechanisms leading those various potential landscape effects, we need to know how bears use cutblocks and unlogged areas. The habitats used by bears are diverse and vary seasonally in importance (Schoen 1990). Documentation of what bears are doing when they are occupying those different landcover types has not been well described.

Bears select open areas in an early successional stage for foraging, whether they have been created naturally (e.g., burns and alpine - Zager *et al.* 1983; Ramcharita 2000; McLellan and Hovey 2001; Heard *et al.* 2008) or are of anthropogenic origin (i.e., cutblocks - Munro *et al.* 2006), where they feed on graminoids and berries (McLellan and Hovey 1995, 2001). Resting appears to be predominately an activity that occurs in forested stands (Munro *et al.* 2006; Heard *et al.* 2008; Mysterud 1983; Mollohan 1986). In Alberta, Cristescu *et al.* (2013) examined the relationship between human-use/risk and bedding sites. They found that, in areas with very low human use, bears bedded in open (herbaceous) areas but selected for horizontal cover in areas of high human use (Cristesu *et al.* 2013). Munro *et al.* (2006) also showed a relationship between bear activity and landcover types for bears in a high human use area in central Alberta. In Alberta, the activity of the bear was found to be dependent upon the habitat type; bedding occurred more in forests and foraging in early seral or open-canopy forests (Munro *et al.* 2006). Temporal differences in activity were also noted. Bears were found to bed more at night than during diurnal and crepuscular periods (Munro *et al.* 2006).

From 1998 to 2003, we studied the habitat use of Grizzly Bears inhabiting the working forests of central interior BC. Clearcut logging, the logging practice in which most or all trees in an area are uniformly cut down, was the primary resource extraction industry throughout the study area. With the exception of two large adult males that travelled back and forth from the plateau to mountainous terrain (Ciarniello *et al.* 2009), the gently rolling plateau was home to a population of Grizzly Bears that lived entirely within the working forest with essentially no alpine, avalanche chutes, or large protected areas. These bears also did not have access to spawning fish. Here we present our site visit observations from a random subset of Grizzly Bear relocations we made between 1998 and 2003, where we identified the primary bear behaviour at each location site as determined by bear sign. In addition to determining the differences in how bears used forested stands (e.g., bedding, feeding or traveling) in comparison to clearcuts and non-forested areas, we documented broad categories of bear forage items in each landcover type.

STUDY AREA

The 8,776 km^2 study area was largely comprised of publically owned Crown forest lands within the Sub-boreal Spruce (SBS) Biogeoclimatic Zone in central British Columbia, Canada (54˚39'N, 122˚ 36'W) (Figure 1). The study area fell within the Prince George Timber Supply Area (PG TSA) and was continually subjected to harvesting with the exception of a few provincial parks where forestry operations were restricted. Those parks were not large enough to contain the home range of a Grizzly Bear. The forestry-based town of Bear Lake (human population, 170) was within the study area and was bisected by Highway 97. Hunting, camping, all-terrain-vehicles and other outdoor recreational opportunities were commonplace.

Until the mid-1950s, the dominant stand-replacing disturbance was wildfires, and possibly Mountain Pine Beetle (*Dendroctonus ponderosae*), but this has since been replaced by active fire suppression and clearcut logging. Historical wildfire patch size ranged between 100 to >10,000 ha with drier western areas having a stand replacement cycle of 100-125 years, and wetter eastern areas, 200-250 years (DeLong 1998, 2002). Clearcut logging patch size were typically 60-100 ha and practices consisted of the traditional two-or-more pass harvesting regime. As a result, the study area was a mosaic of successional stages with mature forest patches interspersed with various aged clearcuts.

The western portion of the study area was drier and the predominant tree stand type was Lodgepole Pine (*Pinus contorta*). Moving eastward, the landscape became wetter and White Spruce (*Picea glauca*) stands were the most common. White Spruce and Subalpine Fir (*Abies lasiocarpa*) or White Spruce and Lodgepole Pine also occurred in mixed stands. Douglas-fir (*Pseudotsuga menziesii*) had largely been harvested and only occurred in small remnants on coarser soils. Aspen (*Populus tremuloides*), Cottonwood (*Populus balsamifera*) and Paper Birch (*Betula papyrifera*) dominated riparian areas and regenerated stands previously disturbed by logging or fires (Meidinger *et al.* 1991). Non-forested but vegetated landscapes consisted of shrubs, herbs and moss. The non-forested and non-vegetated landscape consisted of lakes, rivers, rocks and exposed soil. Elevations ranged from 590 to 1,270 m and there were no alpine or avalanche chutes.

METHODS

Capture and Monitoring

Bears were captured using Aldrich foot snares (Margo Supplies Ltd., High River, Alberta, Canada) placed at baited sites, aerial darting from helicopter, culvert traps, and free-range darting during spring (late April through early June) and fall (September through October) capture events, 1997-fall 2002. Bear capture followed the Canadian Council on Animal Care guidelines and principles and was approved by the University of Alberta's Animal Care Committee (protocol #307204). Capture details are outlined in Ciarniello (2006).

Bears were outfitted with radio-collars (12 channel Televilt GPS-Simplex™ Global Positioning System collar, Televilt/TVP Positioning AB, Lindesberg, Sweden; or a Very High Frequency collar, Lotek, Newmarket, Ontario, Canada). For some bears, we also attached ear-tag transmitters. We monitored bears by tracking the VHF beacon using a single engine fixed-wing aircraft and occasionally a helicopter regardless of collar type. A biologist was present during telemetry flights and efforts were made to obtain low elevation, slow and precise locations. Dependent upon weather conditions, bears were located twice a week from 1998 to 2000, weekly in 2001 and 2002, and every 2 weeks in 2003. Locations where the biologist was not confident of the position of the animal were omitted. We took a Polaroid photograph of each location along with Universal Transverse Mercator (UTM) coordinates with a hand-held 12-channel GPS unit and a back-up UTM with the plane's unit. The photograph and coordinates were used to locate sites on subsequent microsite ground visits.

Microsite Investigations

We visited a random sample of bear VHF relocations to determine how bears were using the landscape at the time of the relocation. We placed the primary stand type into one of

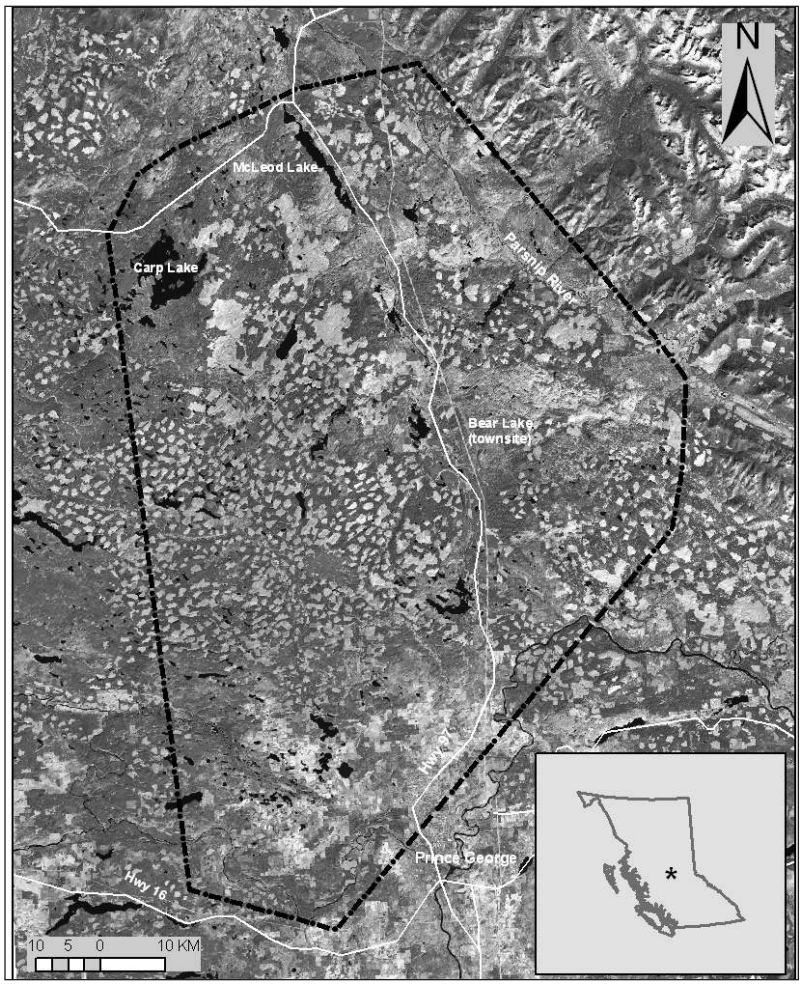

Figure 1. Study area to determine the behaviour of Grizzly Bears in the Prince George Timber Supply Area, British Columbia, Canada, 1998-2003, according to the landcover type in which they were relocated. The patchwork of lighter grey polygons represents the mosaic of clearcuts with lighter blocks being younger than darker blocks.

three categories: (1) clearcuts which included harvested stands ≤40 years of age and relocations along forestry roads, partial cut areas, and pipelines/powerlines that were adjacent to clearcuts; (2) forested stands that had not been harvested and were composed of either deciduous or coniferous trees; and, (3) non-forested areas that were composed of herbs, forbs and shrubs, and included meadows, fields, cleared farmlands and wetlands.

We attempted to visit all sites within a maximum of 7 days of the bear's relocation as long as the bear was not too near the relocation area. In some instances bears remained at scavenging or predation sites longer than 7 days; these sites were visited once the bear was determined to have left the area. We searched the relocation area for bear signs and centered a 10x10 m (100 m2) plot on what we thought was the primary activity of the bear based on a number of criteria including a visual location or telemetry reliability (e.g., the Polaroid photograph taken by the biologist at the time of location with the location of the bear indicated), age of the sign, scat, hair, day beds and or tracks. The primary activity was then subjectively determined based on the amount of bear signs. Bear activity categories included foraging, travelling/moving, mortality of the study bear, resting, rubbing on trees, and other or undetermined. We further delineated the foraging category into the primary forage types: ants, berries, carcass or meat, cambium, digging for roots, grazing vegetation, non-natural anthropogenic attractants, or bees or wasps. We used chi-square tests to make comparisons between bear use of forested, clearcut and non-forested, areas as well as primary foods consumed by bears when using the different landscape types (significance level was considered $\alpha < 0.05$).

Seasons

Locations visited during the active season used here were >1 km from a known den site for spring to 14-July, 15-July to 20-September for summer, and 21-Sept until bears were within 1 km of their den sites for fall. We did not include any investigations that occurred when bears remained <1 km from their den site at den emergence in spring or were within 1 km of their den sites in fall. Den-related behaviours that occurred in late fall/early spring were omitted from these analyses because our earlier work concluded that the majority of den sites were in forested stands >100 years (Ciarniello *et al.* 2005). Since bears tend to loiter around their dens, inclusion of those microsite investigations would have biased our results towards forested sites based on selection for denning attributes rather than how bears were using the landcover type during the non-denning seasons. The types of primary foods consumed were originally used to delineate the seasons (Ciarniello *et al.* 2003). Bears primarily fed on green vegetation in spring, shifting to the consistent use of berries and ants/larvae for summer, and then to a primarily mixed diet in fall (Ciarniello *et al.* 2003). These shifts in primary food consumed were previously determined using the microsite bear use plots and examining bear movements. We used chi-square tests with a significance level of $\alpha < 0.05$ tests to make comparisons between foods consumed by bears.

RESULTS

We gathered 867 VHF locations on 28 (16 female, 12 male) Grizzly Bears outfitted with tracking devices. We conducted ground investigations on 311 sites which represented 36% of the relocations gathered during the active season.

Bear use of clearcuts, forested stands and non-forested areas

During the active season, Grizzly Bears used clearcuts differently than forested stands for foraging, resting, and moving/travelling ($\chi^2 = 21.497$, df: 2, $P<0.0001$). Grizzly Bears also used clearcuts differently than the non-forested areas for foraging and moving/travelling ($\chi^2 = 7.407$, df: 1, $P<0.006$). However, Grizzly Bears used forested stands similarly to non-forested areas for foraging, moving/travelling, and other/undetermined activities ($\chi^2 = 0.772$, df: 2, $P=0.68$). In all landcover types, sample sizes were too small to conduct statistical analyses on Grizzly Bear use of rubbing on trees and mortality of the study bear. Since differences in use of the main activity types that occurred in forested stands and the non-forested areas were not detected, where applicable we combined those landcover types to examine the use of harvested stands versus both of those landcover types.

Bear forage items by landcover type

Foraging was the primary behaviour recorded at the microsites visited (73%, $n = 228/311$). Of the foraging activities, grazing on grasses and forbs was common in clearcuts and forested stands ($\chi^2 = 2.81$, df: 1, $P=0.09$). Digging for roots was also common in clearcuts and forested stands ($\chi^2 = 0.0031$, df: 1, $P=0.96$) and remained common when forested stand were combined with the non-forested areas ($\chi^2_{[grazing]} = 0.95$, df: 1, $P=0.76$; $\chi^2_{[dig]} = 0.002$, df: 1, $P=0.88$; Table 1). Bears fed on more ants/larvae in clearcuts than forested stands ($\chi^2 = 3.90$, df: 1, $P=0.048$) and this relationship became stronger when forested stands were combined with non-forested areas ($\chi^2 = 5.40$, df: 1, $P=0.02$). Conversely, bears fed on more carcasses in forested stands than clearcuts ($\chi^2 = 5.46$, df: 1, $P=0.019$); this relationship became only marginally significant when forested stands were combined with the non-forested areas ($\chi^2 = 3.64$, df: 1 , $P=0.056$). The primary meat item consumed was Moose (*Alces alces*) although we also observed feeding on Black Bears (*Ursus americanus*), a Grizzly Bear road-kill, Beaver (*Castor canadensis*), and birds (*Corvus* spp., *Turdus migratorius*). Surprisingly, we did not detect bears foraging more on berries in clearcuts than forested stands although it was close to significant ($\chi^2 = 3.34$, df: 1, $P=0.07$); however, they foraged on berries more in clearcuts as compared with forested stands combined with the non-forested areas ($\chi^2 = 8.47$, df: 1, $P=0.004$).

Non-foraging behaviours by landcover type

Twenty percent (n = 62/311) of the behaviours we recorded related to non-foraging activities, primarily resting (n = 31/62). Bears infrequently rested in the non-forested areas (n = 3) compared to clearcuts (n = 7) and forested stands (n = 21). Bears rested more in forested stands than clearcuts (X^2 = 14.96, df: 1, P=0.0001). Day beds were usually made in circular depressions with a radius of just less than 1 m. In most cases, shallow excavations or scrapings between 2 and 20 cm deep were made, likely to access moist or cooler soils. Day beds often occurred in alder thickets or forested stands that were adjacent to clearcuts or in association with carcasses.

Bears moved/travelled similarly between clearcuts and forested stands (X^2 = 1.93, df: 1, P=0.16) and clearcuts and non-forested areas (X^2 = 2.07, df: 1, P=0.15). Bears used secondary forestry roads and powerlines to move between areas. We were unable to find evidence of bear use at 6% (n = 4 in clearcuts and 7 each in forested stands and clearcuts) of the plots. On most occasions, we believed the bear was traveling through the area at the time of the location. However, these sites were not classified as traveling unless a trail or tracks were found.

Bear activities by season

We visited 130 locations in spring ($n_{[clearcut]}$ = 57, $n_{[forested]}$ = 43, $n_{[non\text{-}forested]}$ = 30), 126 in summer ($n_{[clearcut]}$ = 61, $n_{[forested]}$ = 40, $n_{[non\text{-}forested]}$ = 25), and 55 ($n_{[clearcut]}$ = 32, $n_{[forested]}$ = 16, $n_{[non\text{-}forested]}$ = 7) in fall. Bear foraging activities were the primary activity identified at 93 (71.5%) plots in spring, 96 (76%) plots in summer, and 39 (71%) plots in fall (Figures 2, 3, 4). In spring, grazing on vegetation was the only activity with a large enough sample size to conduct statistical analysis. Grazing on vegetation occurred more in clearcuts than forested stands in spring but the relationship was only marginally significant (X^2 = 3.67, df: 1, P=0.055; Figure 2). On a few occasions, feeding on over-wintered berries, such as Highbush Cranberry (*Viburnum edule*) was noted in spring. The second highest recorded activity in spring was resting; however, bears rested so infrequently in clearcuts (n = 4, 7%) as compared with harvested stands (n = 12, 28%) that we could not perform a significance test.

In summer grazing on vegetation was common in clearcuts and forested stands (X^2 = 0.012, df: 1, P=0.91; Figure 3). Similarly, feeding on berries was also common in clearcuts and forested stands (X^2 = 1.33, df: 1, P=0.25). Resting appeared to occur more in forests (n = 7, 17.5%) than clearcuts (n = 2, 3%), while foraging on ants/larvae appeared to occur more in clearcuts (n = 13, 21%) than forests (n = 4, 10%). In fall, bears appeared to dig more vegetation ($n_{[clearcut]}$ = 7, 22%; $n_{[forest]}$ = 1, 6%) and feed on more berries ($n_{[clearcut]}$ = 10, 31%; $n_{[forest]}$ = 3, 19%) in clearcuts than forested stands; however, bears appeared to feed more on carcasses in the forest than clearcuts ($n_{[clearcut]}$ = 4, 12.5%; $n_{[forest]}$ = 7, 44%; Figure 4). Overall, bears fed primarily on calf Moose and other Moose of various ages and both sexes.

Commonly encountered bear foods by landcover type

Although bear foods occurred throughout the study area, and bears consumed a diversity of foods, we noted differences in the abundance and distribution of some of the more commonly consumed bear foods within the three broad landcover types (Table 2). In general, the removal of the forest canopy through clearcut logging favoured the regeneration of disturbance related forbs such as Dandelion (*Taraxacum officinale*), Fireweed (*Epilobium angustifolium*) and Clovers (*Trifolium* spp.), which

Table 1. Primary forage item consumed or activity type recorded by Grizzly Bears in clearcuts in comparison with their consumption in forested and/or non-forested areas (clearcuts *vs.* forested; clearcuts *vs.* non-forested; clearcuts *vs.* forested & non-forested combined). Plus (+) signs indicate those items that were fed on more in that landcover type(s) whereas a dash indicates that use was similar between landscapes on the basis of X^2 tests. Blank cells indicate that sample sizes were not large enough for precise results.

Primary Activity Type	Clearcuts	Forested Stands	Non-Forested Areas	Forested & Non-Forested
Forage Type:				
Grazing	—	—	—	—
Digging vegetation	—	—		—
Ants and larvae	+	—		—
Carcass or meat	—	+		+
Berries	—	—		
[1] Berries combined	+			—
Moving/travelling	—	—	—	+
Resting	—	+		+

[1] Clearcuts compared with forested stands and non-forested stands combined

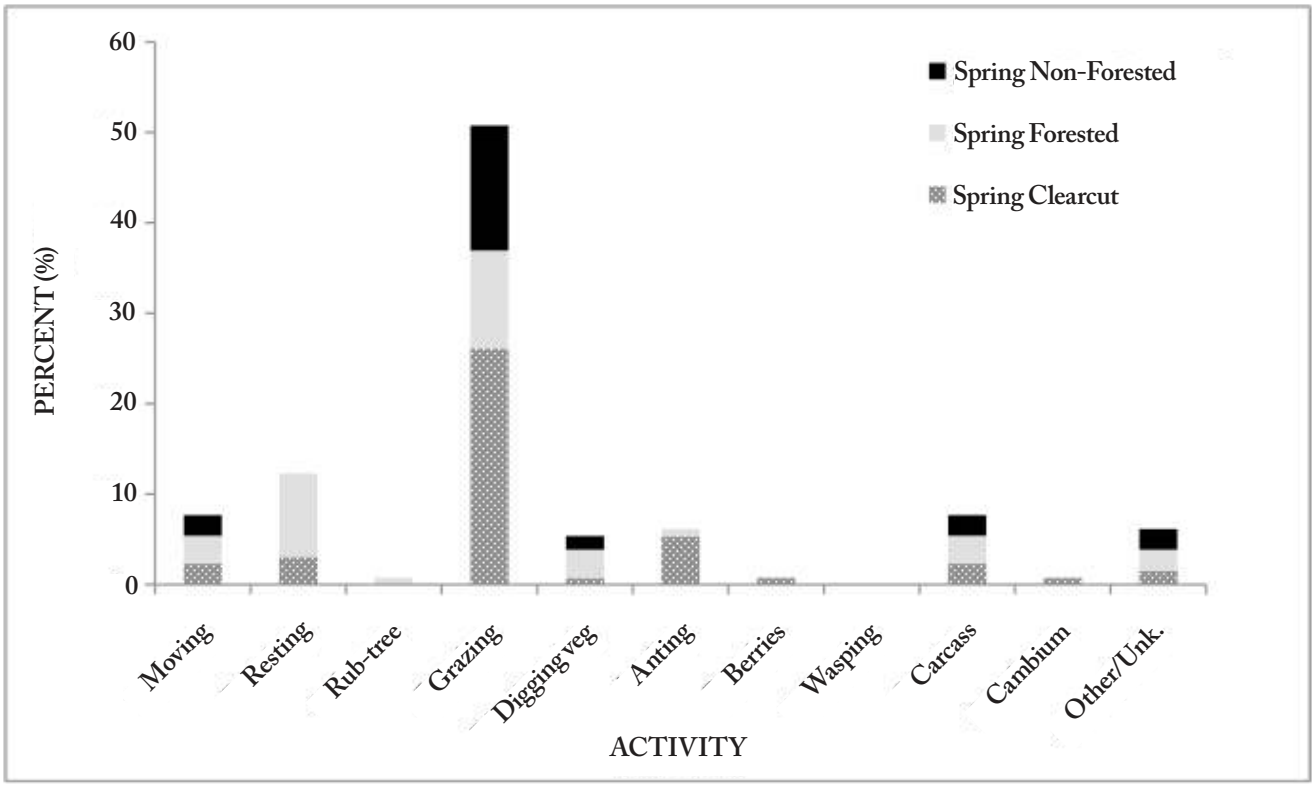

Figure 2. Primary activity identified at Grizzly Bear locations according to the landcover types of clearcuts, forested stands, and non-forested areas in percent for the spring, 1998-2003.

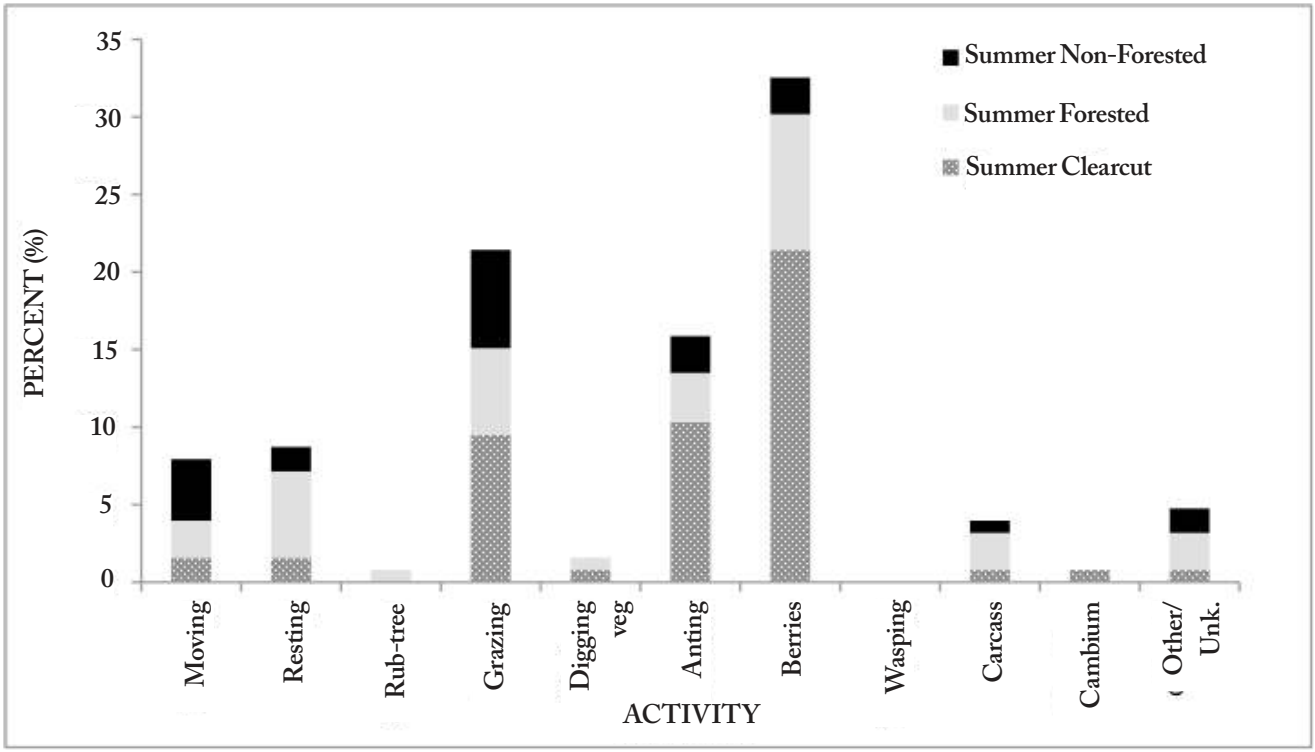

Figure 3. Primary activity identified at Grizzly Bear locations according to the landcover types of clearcuts, forested stands, and non-forested areas in percent for the summer, 1998-2003.

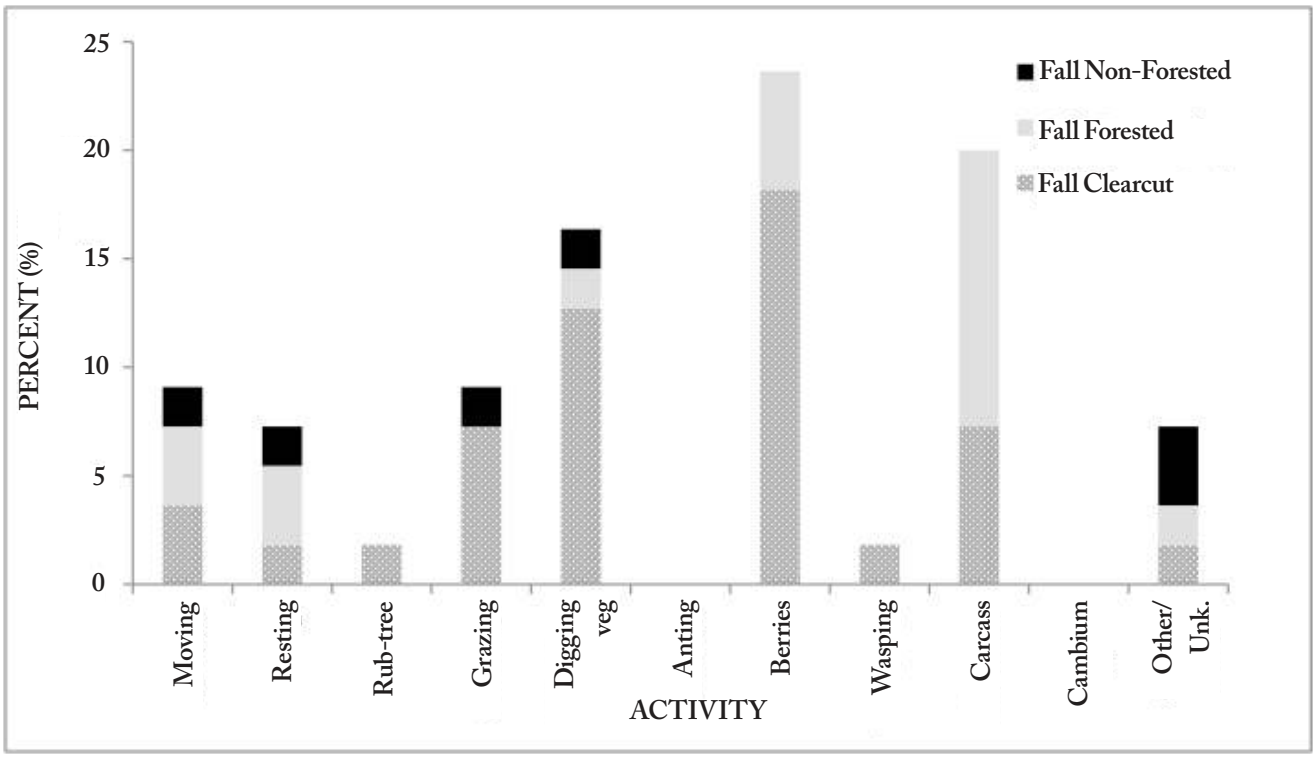

Figure 4. Primary activity identified at Grizzly Bear locations according to the landcover types of clearcuts, forested stands, and non-forested areas in percent for the fall, 1998-2003.

were present along most on-block roads and clearings. Bears ate Dandelions in all three seasons, with intensive use in early spring (emerging leaves), late spring (flower heads) and fall (roots). Blueberries (*Vaccinium* spp.) seemed to be abundant in middle-aged regenerating stands (11 to 20 years) and were favoured by bears in summer through early fall. The berries of Devil's Club (*Oplopanax horridus*) were also commonly fed on by bears in summer; however, those appeared to be more abundant under open forest canopies than in regenerating clearcuts.

DISCUSSION

In general, bears rested in the forest, fed during all seasons in clearcuts, and grazed on grasses and forbs in all of the landcover types. Although foraging in the forest was commonplace, resting in clearcuts or non-forested areas was not. Clearcuts were used by bears for forage during spring, summer and fall, and for traveling along on-block roads. Forest feeding may have been overestimated, and forest resting underestimated, when bears rested in the forest or alder swales adjacent to feeding sites in clearcuts; then the primary activity (e.g., the most amount of bear signs) would have been classified as feeding not resting. Because this bias is opposite to the major trends we observed, we believe our conclusions are conservative/even stronger than the data indicate. Our results would not be biased by bear's circadian rhythm of behaviour and cover use (Munro *et al.* 2006; Heard *et al.* 2008), even though we located bears only during daylight, because we located bears throughout the day. Also, we were comparing the behaviour among landcover types rather than the relative use of those landcover types.

We were surprised that Grizzly Bears did not feed on berries more in clearcuts than forested stands. We suggest this was because we did not quantify berry abundance and productivity at use sites. Our anecdotal observations suggest that Blueberries were far more abundant and productive in clearcuts than the forest; however, if the primary activity was foraging on berries, we accounted for that activity rather than the productivity of the foraging bout. Our observations are supported by the work of Nielsen *et al.* (2004) who reported that differences in berry productivity between cutblocks and forests were dependent upon the type of berry-producing shrub. They found that Black Huckleberry (*V. membranaceum*) was more productive in clearcuts than forests (Nielsen *et al.* 2004). Black Huckleberry and Oval-Leaved Blueberry (*V. ovalifolium*) were major berry-producing shrubs in our study area and occurred in abundance in clearcuts. A second explanation may be related to the berry species consumed by bears. For example, whereas Devil's Club was a major berry producing shrub that was favored by bears in our study area, it is more frequently encountered in moist forests. In contrast, our observations suggest that Blueberries and Huckleberries (*Vaccinium* spp.) tended to be more abundant in

Table 3. Commonly encountered Grizzly Bear foods subjectively placed according to the landcover type they were most often recorded within (clearcuts, forested stands, and non-forested areas) for the Prince George Forest District, 1998-2003.

Latin Name	Common Name	Part Consumed	Landscape
Shrubs			
Amelanchier alnifolia	Saskatoon	Berries	Clearcuts
Cornus stolonifera	Red-osier Dogwood	Berries	Clearcuts and forest gaps
Lonicera involucrata	Bracted Honeysuckle	Berries	Clearcut
Oploplanax horridus	Devil's Club	Berries	Forest
Rubus parviflorus	Thimbleberry	Berries	Clearcuts and forest gaps
Sambucus racomosa	Red Elderberry	Berries	Clearcuts
Vaccinium membranaceum	Black Huckleberry	Berries	Clearcuts
Vaccinium myrtilloides	Velvet-leaved Blueberry	Berries	Forest
Vaccinium ovafolium	Oval-leaved Blueberry	Berries	Clearcuts and forest gaps
Vaccinium oxycocos	Bog Cranberry	Berries	Non-forested
Vaccinium scoparium	Grouse-berry	Berries	Non-forested
Vaccinium uliginosum	Bog Blueberry	Berries	Non-forested
Viburnum edule	Highbush Cranberry	Berries	Clearcuts and forest gaps
Forbs and Grasses			
Aster spp.	Aster Species	Top portion	Non-forested
Astragalus spp.	Milk Vetch	Top portion	Non-forested
Epilobium angustifolium	Fireweed	Top portion	Clearcuts
Equisetum spp.	Horesetail species	Top portion	Clearcuts and non-forested
Heracleum lanatum	Cow Parsnip	Flower head, stalk, leaves	Clearcuts and non-forested
Lathyrus spp.	Pea Vine species	Top portion	Clearcuts
Osmorthiza spp.	Sweet Cicely	Roots	Forest
Taraxacum officinale	Common Dandelion	Flower head, leaves, root	Clearcuts
Tifoilum spp.	Clover, Red & White	Top portion	Clearcuts
Urtica dioica	Stinging Nettle	Top portion	Clearcuts and non-forested
Vicia americana	American Vetch	Top portion	Non-forested
Bromus spp.	Bromes	Top portion	All
Carex spp.	Sedges	Top portion	Non-forested
Poa spp.	Bluegrass species	Top portion	All
Other			
Formicidae	Ants	Ant, larvae	Clearcuts

regenerating clearcuts.

Bears dug similarly for roots in clearcuts and forested stands although we again noted that the forage item was somewhat dependent upon the landcover type; bears dug more for vegetative species that re-colonize after disturbance such as the roots of Dandelion in clearcuts, but they dug more for Sweet Cicely (*Osmorthiza* spp.) in forested stands. We observed that Dandelions were an important disturbance-related recolonizing forb for bears because it was a forage item that could be capitalized on during different seasons. We recorded feeding on Dandelion roots in early spring during the thaw, and in fall after the ground began to freeze. Later in spring, Dandelion leaves and flowers

were fed on. Macronutrients are closely balanced in Dandelions (Coogan *et al.* 2014). Macronutrient intake has been suggested to be important for reproductive success and fitness (Coogan *et al.* 2014). We suggest that the re-colonization of clearcuts by vegetative species that favour disturbance also favour a number of important bear forage items. In addition to Dandelion, some commonly recorded re-colonizing forbs included Pea Vines (*Lathyrus* spp.), clovers, Fireweed, and Vetch (*Vicia americana*).

Bears foraged on more ants/larvae in clearcuts than forested stands. The relationship with ants is likely the result of the large amount of residual decaying tree stumps and logs that follows from forest harvesting activities. Ant abundance has been reported to be significantly higher in clearcuts than forests (Nielsen *et al.* 2004). Conversely, bears fed on more meat (from scavenging or predation) in forested stands than clearcuts. We were unable to determine if the carcasses were kills; however, some may have been predation because the Moose's marrow fat was not indicative of starvation (unpublished data). In fall, bears fed primarily on hunter-killed Moose gut piles and we suggest in our earlier work that bears may have been attracted to hunter kills during this season (Ciarniello *et al.* 2009). Since hunter kills often occurred in clearcuts because of the ease of road access, this increased the records of bears feeding on carcasses in clearcut areas in the fall. Munro *et al.* (2006) also found that bears fed more on ungulates in forested and non-vegetative (similar to our 'non-forested' landcover types) habitats.

Large-scale human disturbances such as forestry may result in the avoidance of adjacent natural habitats by Grizzly Bears (Zager *et al.* 1983; Ramcharita 2000). In our study area the landscape was subjected to repeated harvesting activities (Figure 1) leaving few places where large-scale human disturbances had not occurred. Grizzly Bear behaviour should be considered when examining the mechanisms underlying habitat selection. Bears in this working forest had distinct behavioural activities occurring in one or the other landcover type leading us to conclude that clearcuts and forested stands were both important landcover types. Clearcuts provided foraging benefits for bears while forests provided security, shade, and cover, which make for a good place to sleep.

MANAGEMENT CONSIDERATION

Our results show that maintaining a mixture of forested and open or harvested landcover types probably provides favourable Grizzly Bear habitat (Herrero 1972). The production of early seral forage in clearcuts is important for bears for foraging, and in general, landscapes with more openings have higher bear densities (Mowat *et al.* 2013). Since fire suppression, clearcuts have been the primary generator of early seral conditions and openings. Forestry management operations can be managed to encourage Grizzly Bear use of blocks by allowing or encouraging the re-growth of forbs and shrubs attractive to Grizzly Bears regardless of whether humans classify them as weeds, while also maintaining forested attributes used for bedding sites. To benefit Grizzly Bears inhabiting working forests, we offer the following management recommendations:

- Encourage the growth of berry-producing shrubs within regenerating blocks rather than treating blocks to reduce shrubs and encourage the growth of commercial trees. This management recommendation focuses on regeneration patterns that are similar to a natural burn.
- Encourage the presence of recolonizing forb species that favour disturbance, such as Dandelions. Forage items that span multiple seasons should be of particular importance.
- Do not spray herbicides that reduce the abundance or productivity of bear forage items.
- Maintain some downed debris for colonization by ants.
- Leave some forested areas adjacent to clearcuts that can provide bear bedding sites.

ACKNOWLEDGMENTS

The Parsnip Grizzly Bear Project was funded by Forest Renewal BC and the Forest Investment Accounts with support from Canadian Forest Products Ltd., The Pas Lumber, Slocan Forest Products Ltd. and the McGregor Model Forest Association. Data was gathered as part of L.M. Ciarniello's PhD degree supervised by Dr. M. Boyce. During data collection L.M. Ciarniello received graduate support from the Natural Science and Engineering Research Council of Canada and Province of Alberta Fellowship. Some of the analyses in this manuscript were funded by the Habitat Conservation Trust Foundation. Field and logistical assistance was provided by G. Watts, J. Paczkowski, E. Jones, G. Altoft, L. Frey, D. A. Bears, and volunteers. We thank two anonymous referees and the Editor for their comments.

LITERATURE CITED

Ciarniello, L. M. 2006. Demography and habitat selection by grizzly bears (*Ursus arctos* L.) in central British Columbia. Ph.D. thesis, University of Alberta, Edmonton, Canada.

Ciarniello, L. M., D. Seip, and D. C. Heard. 2003. Parsnip grizzly bear population and habitat project: Summary data sets, 1998 to 2002, including use versus availability. British Columbia Ministry of Forests, Prince George, British Columbia, Canada. Available at: http://web.unbc.ca/parsnip-grizzly/reports.htm. Accessed August, 2014.

Ciarniello, L. M., M. S. Boyce, D. C. Heard, and D. R. Seip. 2005. Denning behaviour and den site selection of grizzly bears along the Parsnip River, British Columbia, Canada. Ursus 16: 47-58.

Ciarniello, L. M., M. S. Boyce, D. C. Heard, and D. R. Seip. 2007. Components of grizzly bear habitat selection: density,

roads, and mortality risk. Journal of Wildlife Management 71: 1446–1457.

Ciarniello, L. M., M. S. Boyce, D. C. Heard, and D. R. Seip. 2009. Comparison of grizzly bear demographics in wilderness mountains versus a plateau with resource development. Wildlife Biology 15: 247–265.

Coogan, S. E., D. Raubenheimer, G. B. Stenhouse, and S. E. Nielsen. 2014. Macronutrient optimization and seasonal diet mixing in a large omnivore, the grizzly bear: A geometric analysis. Plos One 9: e105719.

Cristescu, B, G. B. Stenhouse, and M. S. Boyce. 2013. Perception of human-derived risk influences choice at top of the food chain. Plos One 8:e82738.

DeLong, S.C. 1998. Natural disturbance rate and patch size distribution of forests in northern British Columbia: Implications for forest management. Northwest Science 72: 35-48.

DeLong, S. C. 2002. Natural disturbance units of the Prince George forest region: Guidance for sustainable forest management. Unpublished. BC Ministry of Forests, Prince George, British Columbia, Canada.

Elgmork, K. 1978. Human impact on a brown bear population (*Ursus arctos* L.). Biological Conservation 13: 81-103.

FPPR (Forest Planning and Practices Regulation). Forest and Range Practices Act. 2010. Includes amendments up to B.C. Reg. 269/2010, October 4, 2010. Queen's Printer, Victoria, BC, Canada. Available at: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/12_14_2004 . Accessed March, 2012.

Heard, D. C., L. M. Ciarniello, and D. R. Seip. 2008. Grizzly bear behavior and global positioning system collar fix rates. Journal of Wildlife Management 72: 596-602.

Herrero, S., 1972. Aspects of evolution and adaptation in American black bears (*Ursus americanus* Pallus) and brown and grizzly bears (*Ursus arctos* Linne.) of North America. International Conference on Bear Research and Management 2: 221-231.

McLellan, B. N. 1989. Dynamics of a grizzly bear population during a period of industrial resource extraction. I. Density and age-sex composition. Canadian Journal of Zoology 67: 1856–1860.

McLellan, B. N. 1990. Relationship between human industrial activity and grizzly bears. International Association for Bear Research and Management 8: 57-64.

McLellan, B.N., and F.W. Hovey. 1995. The diet of grizzly bears in the Flathead River drainage of southeastern British Columbia. Canadian Journal of Zoology 73: 704-712.

McLellan, B.N., and F.W. Hovey. 2001. Habitats selected by grizzly bears in a multiple use landscape. Journal of Wildlife Management 65: 92-99.

Meidinger, D., J. Pojar, and W. L. Harper. 1991. Sub-boreal Spruce Zone. Pages 209-221 in D. Meidinger and J. Pojar, editors. Ecosystems of British Columbia. Special Report Series 6. British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Mollohan, C. M. 1986. Characteristics of adult female black bear daybeds in Northern Arizona. International Conference on Bear Research and Management 7: 145-149.

Mowat, G., D. C. Heard, and C. J. Schwartz. 2013. Predicting grizzly bear density in western North America. PLoS ONE 8: e82757.

Munro, R. H. M, S. E. Nielsen, M. H. Prince, G. B. Stenhouse, and M. S. Boyce. 2006. Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. Journal of Mammalogy, 87: 1112-1121.

Mysterud, I. 1983. Characteristics of summer beds of European brown bears in Norway. International Conference on Bear Research and Management 5: 208-222.

Nielsen, S. E. 2011. Relationships between grizzly bear source-sink habitats and prioritized biodiversity sites in Central British Columbia. BC Journal of Ecosystems and Management 12: 136-147.

Nielsen, S. E, M. S. Boyce, and G. B. Stenhouse. 2004. Grizzly bears and forestry II. Distribution of grizzly bear foods in clearcuts of west-central Alberta, Canada. Forest Ecology and Management 199: 67-82.

Ramcharita, R. K. 2000. Grizzly bear use of avalanche chutes in the Columbia Mountains, British Columbia. MSc thesis, University of British Columbia, Vancouver, British Columbia, Canada.

Schoen, J. W. 1990. Bear habitat management: a review and future perspective. International Conference on Bear Research and Management 8: 143-154.

Stewart, B. P., T. A. Nelson, M. A. Wulder, S. E. Nielsen, and G. Stenhouse. 2012. Impact of disturbance characteristics and age on grizzly bear habitat selection. Applied Geography 34: 614-625.

Wielgus, R. B., and P. Vernier. 2003. Grizzly bear selection of managed and unmanaged forests in the Selkirk Mountains. Canadian Journal of Forest Research 33: 822-829.

Zager, P., C. Jonkel, and J. Habeck. 1983. Logging and wildlife influence on grizzly bear habitat in northwestern Montana. International Conference on Bear Research and Management 5: 124-132.

ABOUT THE AUTHORS

Lana M. Ciarniello has conducted research on Black Bears and Grizzly Bears in a number of provinces/territories throughout Canada since 1993. She received a MEDes from the University of Calgary in 1996, and a PhD from the University of Alberta in 2006. Her research interests focus on the interaction of humans and bears, particularly as they relate to resource extraction

industries and urban expansion. Lana believes in science-based management of bears. She is Co-Chair of the Human-Bear Conflicts Expert Team for the International Union of the Conservation of Nature's (IUCN) Bear Specialist Group, and the sole proprietor of Aklak Wildlife Consulting based in Campbell River, British Columbia.

Douglas Heard has been a wildlife biologist with the Ministry of Forests Land and Natural Resource Operations in British Columbia, and Adjunct Professor in the Ecosystem Science & Management Program at the University of Northern British Columbia (UNBC) for the past 22 years. He received his MSc from the University of British Columbia in 1978. His research interests center on how the risk of predation from Gray Wolves (*Canis lupus*) and bears affects the behaviour and population dynamics of ungulates. After 16 years in the Northwest Territories and Nunavut, studying Barren-ground Caribou (*Rangifer tarandus groenlandicus*) and Musk Ox (*Ovibos moschatus*), he moved to British Columbia where he expanded his interests to include Moose (*Alces alces*) and Mountain Goats (*Oreamnos americanus*).

Dale Seip is a wildlife biologist with the BC Ministry of Environment. He conducts research on the conservation and management of wildlife in central BC He has worked on Woodland Caribou (*Rangifer tarandus tarandus*), Grizzly Bears, Stone's Sheep (*Ovis dalli*), and forest biodiversity.