The ecology of grizzly bears and black bears in the Cooke City, Montana area
by Steven Richard Yonge

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
The Cooke City Basin in the northeast comer of the Greater Yellowstone Ecosystem (GYE) is characterized by high quality whitebark pine (Pinus albicaulis) foraging areas for grizzly bears (Ursus arctos horribilis) and black bears (Ursus americanus), as well as high levels of human activity and important mineral deposits. During the preparation of the Environmental Impact Statement (EIS) for the proposed New World Mine, the Gallatin National Forest (GNF) conducted a base line study during 1990 and 1991 addressing bear habitat use and the distribution of bears in relationship to human activity. I repeated the study during 1996 and 1997 to increase the number of years for a pooled sample and to determine if bear habitat use patterns had changed since 1990-1991 in response to increased human use. Although the effects of roaded habitat on bears are well documented, I investigated bear foraging strategies in pursuit of a high quality food source in areas with high road densities. Bear activity was surveyed by walking a series of line transects established within eight drainages adjacent to Cooke City, Montana. The density of bear activity was similar between the 1990-1991 and 1996-1997 periods. However, bear activity was not distributed evenly throughout the study area subunits. Food habits analysis indicated the importance of whitebark pine seeds during spring and fall, verified by the greater amount of bear activity recorded in mature whitebark pine cover types,. Herbaceous material was common during all months, with peak occurrence in summer feces. Bear activity was equally distributed among “core” (unroaded) and “non-core”(roaded) habitat. Black bears were less influenced by human activity levels than grizzly bears. The tendency of grizzly and black bears to avoid open areas more than roaded forest areas suggested that forested cover played a greater role in bear habitat utilization in the Cooke City Basin than road density. Cover and the availability of high quality foods mitigates the risk bears will take to acquire whitebark pine seeds in the Cooke City Basin.

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Fish and Wildlife Management

MONTANA STATE UNIVERSITY
Bozeman, Montana

May 2001

APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGEMENTS

I would like to thank my wife Veronica, for sacrificing so much and standing by my side through this arduous adventure. Veronica is a special woman and I could not have accomplished what I have with out her love and friendship. I would like to thank the following people for their guidance and contribution to this study: Dan Tyers, USFS, for providing me with this great opportunity, technical and logistical support, and his generous nature; Tris Hoffman, her patience, GIS knowledge, and friendship was invaluable; Dan Reinhart, NPS, for generously sharing his original data and helping initiate my study; my graduate committee, Drs. Lynn R. Irby, Robert Garrott, and Thomas McMahon; the dedicated student interns, Jeremy Zimmer, Sarah Coburn, Mathew Tyers, Jack Hopkins, Ryer Rens, Aarron Tewell, Nicolle Smith, Jeannie Heltzel, David Suskin, Sarah Elmendorph, and Melanie Weeks; Ellen Snoeyenbos, USFS, who performed data entry; Collen Stein and J.T. Stangl, USFS, for assisting with analysis; Kevin Frey, MFWP, who performed food habits analysis; the IGBST, who funded food habits analysis during 1996; and Dr. Harold Picton and the Chemical Analytical Laboratory, MSU, Bozeman, who conducted thin layer chromatography. I would also like to express my appreciation to John and Kathryn Harris for sponsoring the invaluable student interns that helped with fieldwork.

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ABSTRACT

The Cooke City Basin in the northeast corner of the Greater Yellowstone Ecosystem (GYE) is characterized by high quality whitebark pine (*Pinus albicaulis*) foraging areas for grizzly bears (*Ursus arctos horribilis*) and black bears (*Ursus americanus*), as well as high levels of human activity and important mineral deposits. During the preparation of the Environmental Impact Statement (EIS) for the proposed New World Mine, the Gallatin National Forest (GNF) conducted a base line study during 1990 and 1991 addressing bear habitat use and the distribution of bears in relationship to human activity. I repeated the study during 1996 and 1997 to increase the number of years for a pooled sample and to determine if bear habitat use patterns had changed since 1990-1991 in response to increased human use. Although the effects of roaded habitat on bears are well documented, I investigated bear foraging strategies in pursuit of a high quality food source in areas with high road densities. Bear activity was surveyed by walking a series of line transects established within eight drainages adjacent to Cooke City, Montana. The density of bear activity was similar between the 1990-1991 and 1996-1997 periods. However, bear activity was not distributed evenly throughout the study area subunits. Food habits analysis indicated the importance of whitebark pine seeds during spring and fall, verified by the greater amount of bear activity recorded in mature whitebark pine cover types. Herbaceous material was common during all months, with peak occurrence in summer feces. Bear activity was equally distributed among "core" (unroaded) and "non-core"(roaded) habitat. Black bears were less influenced by human activity levels than grizzly bears. The tendency of grizzly and black bears to avoid open areas more than roaded forest areas suggested that forested cover played a greater role in bear habitat utilization in the Cooke City Basin than road density. Cover and the availability of high quality foods mitigates the risk bears will take to acquire whitebark pine seeds in the Cooke City Basin.

INTRODUCTION

From the inception of Yellowstone National Park (YNP) in 1872 until the 1970's, garbage was deliberately or casually made available to grizzly bears (*Ursus arctos horribilis*) and black bears (*Ursus americanus*). Consequently, dumps were an important food source for several generations of Yellowstone bears. The closure of dumps in and around Yellowstone and the subsequent dramatic grizzly bear population decline generated considerable controversy and was a major factor in the 1975 listing of the grizzly bear in the lower 48 states under the Endangered Species Act (Mattson and Reid 1991, Schullery 1992, Eberhardt and Knight 1996). Attempts by Federal and State agencies to protect the Yellowstone grizzly bear appear to have been successful in increasing numbers of bears. Recent evidence suggests that the Yellowstone grizzly population may be at or near carrying capacity in YNP (Mattson and Reid 1991). If the population in YNP is near carrying capacity, the demand for preferred habitat and food resources outside YNP has likely increased.

Human demands for resources have also increased in the Greater Yellowstone Ecosystem (GYE) exacerbating the potential for bear / human conflicts. Extraction of commodities such as timber and minerals leads to more roads and altered habitat. A growing interest in nonconsumptive recreational pursuits that result in a proliferation of human activity in roaded and non-roaded areas has also increased [Dan Tyers, Gallatin National Forest (GNF), pers. comm.].

Competition among bears for preferred habitat is based on social status. Mature males can exclude other bears from habitat that is productive and secure from humans. Other classes of the population, including females with cubs and subadults, appear to avoid males and use the remaining habitat where risks associated with human encounters are greater and foraging is energetically more stressful (Mattson and Reid 1991, Mattson 1993). Land ownership patterns, agency management restrictions, and commercial enterprise have centralized some human activities in the GYE. Females with cubs, the focus of population conservation efforts, may have developed foraging strategies to utilize these areas. Therefore, minimizing human-caused bear mortalities requires understanding bear habitat use in the more developed portions of the GYE.

The Cooke City Basin in the northeast corner of the GYE presents a management dilemma. How does one encourage an expanding grizzly population in an area with high levels of human use? High quality whitebark pine foraging areas for grizzly and black bears as well as high road densities and levels of human activity define this area. It is already an identified population sink (Knight et al. 1988). Significant amounts of forest cover have been removed through the 1988 Yellowstone fires and subsequent salvage logging. I used the Cooke City Basin to investigate bear foraging strategies in a disturbed area with high quality natural foods where foraging risks may be greater than in the surrounding designated wilderness.

Although heavily roaded, whitebark pine habitat in the Cooke City Basin offers a critical food source to bears. Whitebark pine seeds are an important spring and fall food for grizzly and black bears in the GYE (Craighead and Craighead 1972, Mattson and Jonkel 1990, Mattson et al. 1991, Mattson and Reinhart 1996). Grizzly bear survival and fecundity is dependent upon the whitebark pine cone crop (Mattson and Reinhart 1996). Mattson et al. (1992) reported a strong correlation between poor whitebark pine cone production and increased bear management actions and mortality. However, cover may provide the concealment and security necessary for bears to successfully feed on important natural foods while moving inconspicuously near roads and human developments.

Roads and cover have been identified as important determinants of bear habitat use. Mattson et al. (1987) and Mattson et al. (1992) found that road density, traffic volume, and seasonal food availability affected bear movements and foraging strategies in the Yellowstone area. On the East Front of the Rocky Mountains, Schallenberger and Jonkel (1980) reported the average distance of grizzly bear radio locations from automobile and 4 wheel drive roads was 3.4 km and 6.2 km, respectively. In YNP, grizzly bears avoided habitat within 500 m of primary roads during spring and fall (Mattson et al. 1987). In the Cabinet Mountains of northwestern Montana and northern Idaho, Kasworm and Manley (1990) discovered that black bears used habitat < 274 m from roads less than expected during spring and habitat < 914 m from roads less than expected during fall. In the Swan Mountains of Montana, Mace et al. (1996) reported that bears avoided habitat near roads with traffic volumes exceeding 60 cars per day. The northeast entrance of YNP, located on Highway 212, receives vehicle traffic similar to the Swan Mountains study area (USDOT 1998).

McLellan and Shackleton (1989) found that cover was an important factor in mitigating grizzly bear responses to human activity. Bears showed a strong response to human activity at distances of < 150 m in open habitat. In contrast, bears in cover showed no reaction to human activity at the same distance. Blanchard (1983) found that 90% of radio collared grizzly bear locations in YNP between 1977-1979 were in timbered cover. Blanchard (1983) also reported that of 191 grizzly observations in open habitat, 75% were < 100 m from forest cover.

To compensate for human activity and lack of cover, bears may increase nocturnal movements and decrease diurnal traveling. McLellan and Mace (1985) found that bears used roads more frequently at night. Schleyer (1983) reported that YNP grizzly bears demonstrated nocturnal habits with crepuscular peaks. However, YNP black bears were predominately diurnal during summer months (Schleyer 1983).

In response to these data, government agencies have attempted to regulate vehicle access to protect bears and bear habitat. Less attention has been given to bear requirements for cover. Management guidelines for road density and proportions of unroaded to roaded areas have been established for the GNF (IGBC 1998). However, their effectiveness in relation to bear use of cover, roaded landscapes, and important food sources is poorly understood.

In 1990, Noranda Minerals Inc. proposed the development of the New World Mine, to extract precious metals from Mount Henderson, Cooke City Basin. As part of the effects analysis for the Environmental Impact Statement (EIS), the GNF conducted a baseline study of grizzly and black bear habitat use during 1990 and 1991 (Reinhart and Mattson 1992). The study used line transects to record bear habitat use and addressed bear activity, habitat parameters, and the relationship between existing human activities and bear distribution in the vicinity of the New World Mine. However, the proposed mineral extraction project was removed from consideration by direct intervention of President Clinton in 1996 (USDI and USDA 1997). Although mining activity has ceased, other human activities including mining reclamation will continue to influence grizzly and black bear habitat use in the Cooke City Basin.

In 1996 and 1997, I repeated transects established for the New World Mine EIS baseline study (Reinhart and Mattson 1992) to contrast bear habitat use patterns between the two sample periods and to increase the number of years for a pooled sample. These data should assist managers attempting to protect bears in the GYE, an environment where competition for resources among bears and between bears and humans is increasing. Specifically, they should provide insights into the effects of roads and cover on bear habitat use.

My study objectives were:

1. Compare levels of bear activity between the two study periods.
2. Examine bear cover type use versus availability.
3. Identify and summarize important seasonal food habits.
4. Examine the effects of road density, core habitat, and cover on bear activity distribution.

STUDY AREA

The Cooke City study area was located 6 km (4 miles) from YNP's northeast entrance and encompassed 91 km^2 (Reinhart and Mattson 1992) within the Yellowstone Grizzly Bear Recovery Zone (USFWS 1993) (Fig. 1). The terrain and climate were characteristic of an intercontinental high elevation environment at the 45th parallel. Steep, rugged mountains and valley bottoms were the common landforms. The valley floor elevation was 2,427 m (7,400 ft.) and adjacent peaks exceeded 3,477 m (10,600 ft.). Although a portion of the Absaroka Range, my study area was located at the geologic break with the Beartooth Plateau, an extensive alpine region dominated by tundra and rock. The Beartooth Plateau consists of Precambrian granite gneiss and unmetamorphosed granite dated to approximately 2.7 billion years. The Cooke City structural zone is Paleozoic sedimentary rock and Tertiary volcanics (USDI and USDA 1997). The area was glaciated during the Pleistocene period, forming cirques, valleys, glacial lakes, and morainal deposits. Alluvial and colluvial material was common throughout the study area (USDI and USDA 1997).

Vegetation was a mosaic of forested community types fragmented by talus slides, avalanche chutes, nonforested openings, and alpine meadows. Forested areas at upper tree line consisted of krumholtz Engelmann spruce (*Picea engelmannii*), whitebark pine (*Pinus albicaulis*) and subalpine fir (*Abies lasiocarpa*). Mature to old growth stands of Engelmann spruce, whitebark pine, subalpine fir, and lodgepole pine (*Pinus contorta*) occurred at mid to low elevations (Reinhart and Mattson 1992). Extensive burned areas (Yellowstone fires of 1988) were found to the north and northeast of Cooke City at lower elevations. Avalanche chutes were dominated by subalpine fir and Engelmann spruce and accompanied by a grouse whortleberry (*Vaccinium scoparium*) understory (Reinhart and Mattson 1992). Alpine meadows supported a

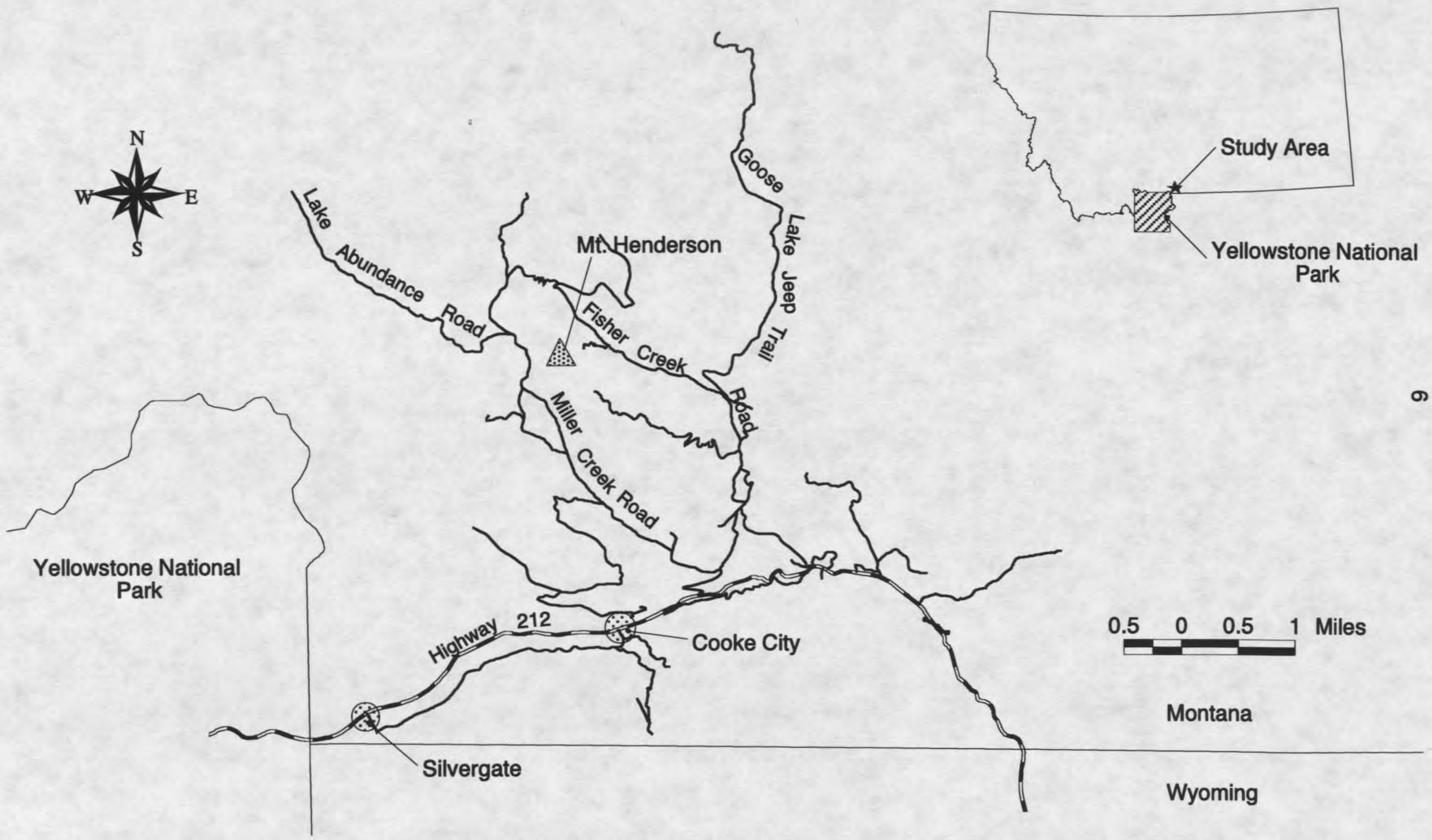

Figure 1. The Cooke City study area with landscape features and place names mentioned in the text.

variety of forb and grass species with species composition dependent on moisture content and soil type. Wet meadows occurred at the upper reaches of most streams. Willow (*Salix* spp.) communities were found in lower elevation riparian zones (Reinhart and Mattson 1992). Moist to dry forest openings, dominated by forbs and grasses, were common throughout the forest matrix.

Forest Service land management restrictions allowed for a wide variety of human activities and facilities, including timber harvesting, motorized travel, dispersed recreation, developed campgrounds, and until recently, mineral extraction (USDA 1987). In contrast, the surrounding areas were unroaded and part of the Absaroka-Beartooth and North Absaroka Wilderness areas of the Gallatin, Custer, and Shoshone National Forests (Reinhart and Mattson 1992). The remainder of the Basin was juxtaposed with YNP (USDI and USDA 1997). Most of the valley floor was in private ownership. In addition to commercial and residential pursuits, human activity while I collected data (1996 and 1997) included hiking, camping, backpacking, hunting, horseback riding, snowmobiling, cross-country skiing, four-wheel driving, and firewood cutting.

There was an extensive system of private, county, and Forest Service roads in the Cooke City Basin, most of which was constructed during a period of intense mining activity that originated in 1864 and ended with the closure of the McLarens mine in 1953 (USDA 1999). Two maintained county roads (Miller Creek and Fisher Creek) connected at Daisy and Lulu Pass and provided a popular vehicle loop route (USDI and USDA 1997). Primitive roads (Lake Abundance and Goose Lake jeep trail) accessed the edge of the Absaroka-Beartooth Wilderness. Vehicle use on all roads was greatest during July through mid-September (USDI and USDA 1997).

Forest Service developed recreation sites encouraged visitor use. Three campgrounds (Soda Butte, Colter, and Chief Joseph) in and adjacent to the study area received approximately 9,000 visitors annually (USDI and USDA 1997). Four trailheads (Lady of the Lakes, Republic

Pass, Lake Abundance, and Clarks Fork), provided access to a network of backcountry trails. Approximately 7,000 recreation visits were recorded at the Clarks Fork trailhead in 1995 (USDI and USDA 1997).

Highway 212, a National Scenic Highway, bisected the study area. Approximately 5-7% of the 3 million visitors annually entered Yellowstone via this route (USDI and USDA 1997). Three settlements (Cooke City, Silver Gate, and Colter Pass) were along the highway and within the Basin. There were approximately 124 year round residents and 318 seasonal residents living primarily along the road corridor. The 1990 census estimated 277 housing units and projected 3-4 new homes/cabins would be built per year on private lands (USDI and USDA 1997).

After the Yellowstone fires of 1988, logging increased (USDI and USDA 1997). Salvageable burned timber was removed from the lower portions of the Fisher and Miller Creek drainages starting in 1990 (Reinhart and Mattson 1992). Post-fire reforestation projects involved planting conifer seedlings throughout the same area until 1996 (Roger Gown, GNF, pers. comm.).

Whitebark pine, an important forest component in the study area, is an extremely valuable food source for bears within the GYE and the Cooke City Basin (Kendall 1983). Approximately 947 ha of mature and 20 ha of immature whitebark pine forest existed in and adjacent to the study area in 1995 (USDI and USDA 1997). The whitebark pine zone occurs in the upper subalpine and timberline areas between 2,440-2,870 m (8,006-9,416 ft). This elevational gradient averages < 0° C, is extremely windy, and is subjected to significant snow accumulations (Weaver 1990).

Other carnivores common to the study area included coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and mountain lions (*Felis concolor*). Wolverines (*Gulo luscus*) and gray wolves (*Canis lupus*) may also have used the area but were rare (USDI and USDA 1997). The area supported a variety of ungulates, including bighorn sheep (*Ovis canadensis*), mountain goats (*Oreamnos americanus*), mule deer (*Odocoileus hemionus*), Shiras moose (*Alces alces shiras*) and elk (*Cervus elaphus*). The red squirrel (*Tamiasciurus hudsonicus*) and Clark's nutcracker (*Nucifraga columbiana*), two species responsible for whitebark pine consumption and dispersal (Kendall 1983, Reinhart and Mattson 1990), were also common.

METHODS

Study Area Subunits

The Cooke City study area was divided into eight subunits based on geographic location and hydrologic divides (Reinhart and Mattson 1992) (Table 1, Fig. 2). Each subunit was adjacent to or within the original New World Mine project area and was established to assess the potential impacts mining activity would have on the surrounding area.

Table 1. The eight subunits where bear activity was recorded.

Subunit	Location Description
Fisher Creek	Upper portion of the Fisher Creek drainage above the Fisher Creek bridge crossing to Lulu Pass.
Miller Creek	Upper portion of the Miller Creek drainage to Daisy Pass.
Mud Lake	Area northeast of Fisher Creek, encompassing the Goose Lake jeep trail and a series of high mountain lakes, including Round Lake, Ovis Lake, Mud Lake, and Corner Lake.
Sheep Creek	Upper portion of the Sheep Creek drainage above Sheep Creek Falls.
Stillwater	Headwaters of the Stillwater River, below Crown Butte to Lake Abundance.
Republic Creek	Republic Creek drainage to Republic Pass.
Woody Creek	Woody Creek drainage including the area southeast of Cooke City to Colter Pass.
Cooke Face	Lower portion of the Sheep, Fisher, and Miller Creek drainages northwest of Cooke City.

Data Collection

I used line transects to determine bear distribution patterns following procedures reported in Reinhart and Mattson (1992). A USGS 15-minute topographic map and 1:30,000 color aerial

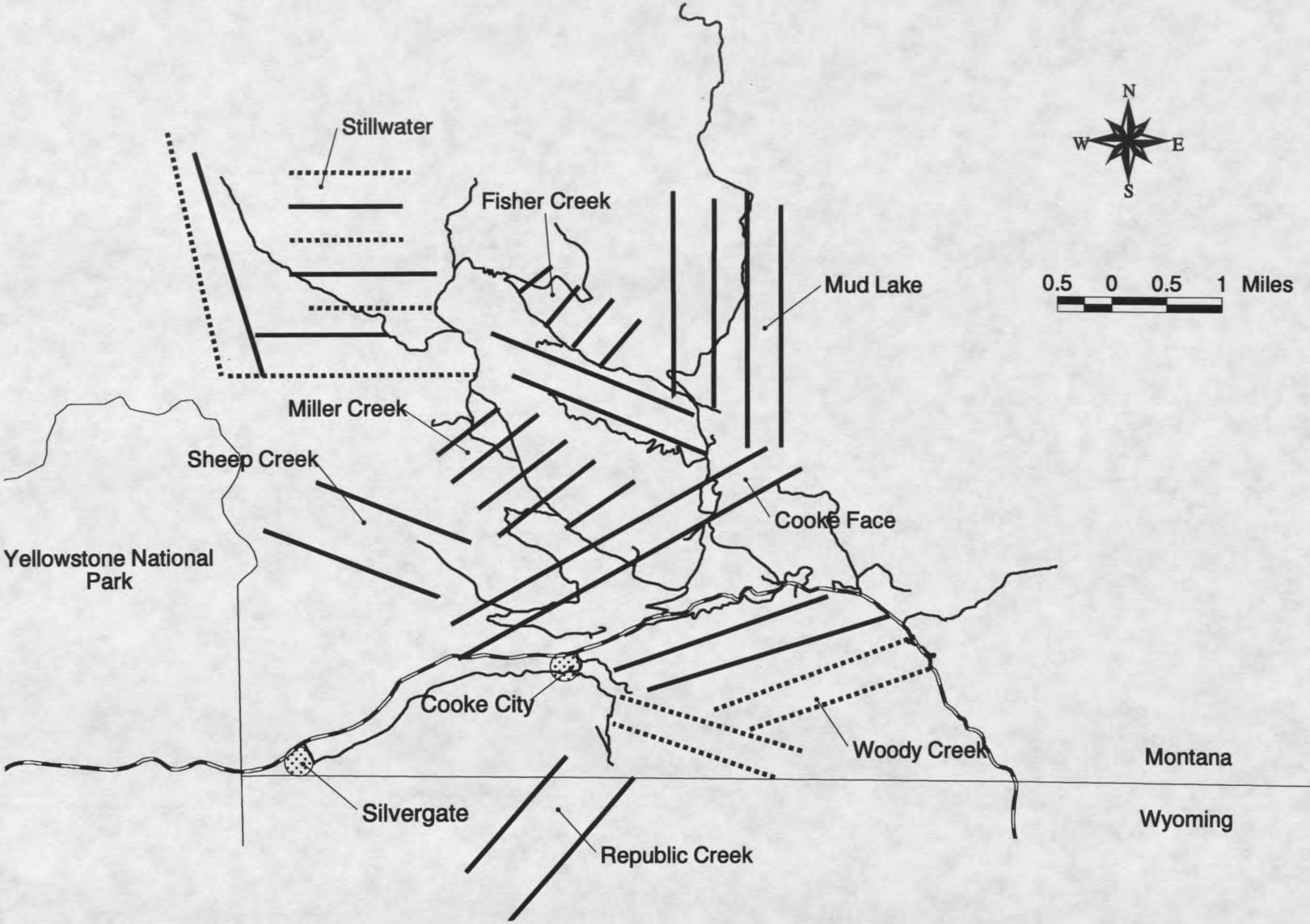

Figure 2. The location of the original 36 transects within the 8 subunits sampled during 1990 and 1991 by Dan Reinhart. The solid transect lines represent transects I resampled in 1996 and 1997.

photos were used to establish line transects within each subunit. Transects were placed 0.5 to 1.0 km apart and oriented perpendicular or parallel to topographic contours to cover elevational gradients within the eight subunits. Transect placement was dictated by landscape attributes, and no attempt was made to include or exclude specific habitat types. Transect length was determined by measurements on aerial photographs and topographic maps corrected for slope (Reinhart and Mattson 1992).

Line transects were sampled at approximately one month intervals to monitor the seasonal pattern of bear activity. Bear activity consisted of tracks, scat, daybeds, excavated red squirrel middens, bear sightings, torn logs, and feeding sites (Reinhart and Mattson 1992). Reinhart sampled 36 line transects (97 km) from June 25 to September 27 during 1990 and from June 20 to October 23 during 1991 (Reinhart and Mattson 1992). Reinhart sampled transects 2-4 times ($\bar{x}$=3.28) in 1990 and 4-5 times ($\bar{x}$=3.33) in 1991, covering a total of 295 km and 404 km, respectively (Reinhart and Mattson 1992).

I resampled 25 of the original 36 line transects (63 km) in 1996 and 27 transects (74 km) in 1997. I consulted with Reinhart to determine which transects should be repeated during 1996 and 1997. I repeated all transects in the Fisher Creek, Mud Lake, Miller Creek, Republic Creek, and Sheep Creek subunits. I resampled 4 of 9 transects within the Stillwater subunit, 2 of 6 transects in the Woody Creek subunit, and repeated the Cooke Face transects in 1997 (Fig. 2). I conducted fieldwork from July 17 through October 9 during 1996 and from July 5 through October 17 during 1997. I surveyed transects 3-4 times during 1996 ($\bar{x}$=3.52) and 1997 ($\bar{x}$=3.37) and sampled a total of 216 km and 249 km, respectively.

In both sampling periods, a transect compass bearing was held by one observer while another walked a zigzag pattern documenting bear activity. Bear activity was sampled out to 250 m from the transect line. Community site analysis was conducted at each bear activity site.

elevation, cover type (Mattson and Despain 1985), habitat type (Pfister et al. 1977), distance to nonforested/forested opening, burned/unburned forest designation, topographic position (ridge, upperslope, midslope, lowslope, bench, or bottom), and general site description (Appendix A, Fig. 16). Bear activity was dated to the approximate time of occurrence. When possible, bear tracks [Palmisciano technique (Brown 1993)], bear sightings, and hair samples were used to distinguish between black bear and grizzly bear activity sites. Thin layer chromatography (TLC) was used to differentiate between grizzly and black bear scats collected during 1991 (Reinhart and Mattson 1992), 1996, and 1997. All bear scats recorded by Reinhart and myself were collected for diet composition analysis.

The line transect survey method has been used in previous studies to assess wildlife abundance and population size (Eberhardt 1978, Roth 1980, Reinhart and Mattson 1990). Indirect measures have been an effective method used to compare animal abundance and habitat use patterns between areas and time periods (Halvorson 1984). My inability to differentiate grizzly bear from black bear sign did limit my interpretation of habitat use patterns and food habits. Thin layer chromatography alleviated some of these problems for identifying bear scats. Habitat utilization analysis was also affected by the probability of sign detection. Bear travel and grazing activity along with the associated habitat is potentially under represented due to the inconspicuous nature of this type of sign (Reinhart and Mattson 1992).

Despite its limitations, the line transect method is a cost-effective monitoring technique, and is relatively simple to repeat and logistically inexpensive, when compared to intense telemetry movement studies. This method is also less intrusive to the animal and is capable of capturing the annual variation in bear use patterns, habitat parameters, and overall bear food habits.

Thin Layer Chromatography Analysis

Thin layer chromatography was used to identify species (distinguishing grizzly from black bear) of bear scat collected in 1991,1996, and 1997. Mr. Laszlo Torma and staff from the Chemical Station Analytical Laboratory (Montana State University) prepared the chromatograms. Dr. Harold Picton (Emeritus Professor of Wildlife Management, Montana State University) read and interpreted the chromatograms and reported results. Procedures for TLC are reported in Picton (1991). The size and diameter of a bear scat is not considered a positive indicator for identifying species of bear (Hamer et al. 1981, Picton 1991), due to variation attributed to scat composition, moisture level, and scat age. Typically, one scat was analyzed from a group of scats collected from an activity site, and I assumed all other scats were deposited from the same individual bear. If a discrepancy existed (difference in scat size, fecal composition, or scat age) between scats within a scat grouping, multiple scats were analyzed. Scats were air dried, ground for 1 minute in a blender, and stored in film containers to deliver to the Chemical Station Analytical Laboratory. Picton's (1991) scat-key 12.1 was used to distinguish between black and grizzly bear scats. TLC results ranged from 100% to 56% probability for positive species identification. Results with a probability of ≤ 60% were cross referenced with field data summaries and deemed "unknown" if the bear sign was not classified by species in the field.

Density of Bear Activity

I calculated linear densities (n/km) (Reinhart and Mattson 1992) of bear activity incidence collected along transect routes. I compared levels of density among the eight subunits using data collected by Reinhart only from transects I repeated in 1996 and 1997 (Fig. 2). I compared levels of density between aggregated sample periods (1990-1991 versus 1996-1997) and between "good" (1991/1996) and "poor" (1990/1997) years of whitebark pine cone production using the nonparametric Wilcoxon paired rank test. I defined years of "good" whitebark pine cone production as years when cones averaged $\geq$ 13 cones per tree on IGBST monitored permanent transects. Mattson and Reinhart (1994) reported that when cones average >13-23 per tree, significant use by bears was observed. Years with <13 cones per tree were deemed "poor" cone production years. I then pooled all four years of bear activity site data and compared the density of bear activity among the eight subunits using the nonparametric Kruskal-Wallis test. Statistical significance was accepted at $P < 0.05$.

Cover Type Use – Availability Analysis

I utilized a 16,000 ha vegetation map developed as part of the New World Mine environmental assessment to assess grizzly and black bear cover type use versus availability. The vegetation map was verified by ground truth observations and mapped to a 2-acre polygon resolution. One hundred and twelve cover type combinations were recognized within the 250 m buffered area around all 36 transects. I consolidated cover types into 10 categories (Table 2) to facilitate analysis. Vegetative mosaics were designated when more than one cover type was in juxtaposition to another, where there was no true dominant cover type, or to identify vegetative ecotones.

I pooled all of Reinhart's bear activity data, including data from transects I did not repeat, and the data I collected during 1996 and 1997 and tested for goodness-of-fit of cover type use. I then pooled bear activity sites recorded during years of "poor" (1990/1997) and "good" (1991/1996) whitebark pine cone production and tested for goodness-of-fit. To capture potential differences in cover type use versus availability during the 1990-1991 and 1996-1997 periods, I separately tested for goodness-of-fit. I then pooled all grizzly bear activity locations recorded by Reinhart and myself and compared cover type use versus availability. Use versus availability analysis followed procedures described by Neu et al. (1974). Statistical significance was accepted at $P < 0.05$.

Table 2. Cover type categories where grizzly bear and black bear activity sites were recorded. For complete cover type definitions see Mattson and Despain (1985).

Cover Type	Description
Mature whitebark pine	Mature whitebark pine forest; contains Engelmann spruce, subalpine fir, and lodgepole pine.
Mature whitebark pine mosaic	Mature whitebark pine forest in a mosaic of other vegetative components.
Mature subalpine fir	Mature subalpine fir forest. May contain lodgepole pine, whitebark pine, and Douglas fir (*Pseudotsuga menziesii*).
Mature subalpine fir mosaic[a]	Mature subalpine fir forest in a mosaic of other vegetative components.
Disturbed subalpine fir mosaic	Wet or burned spruce and subalpine fir forest in a mosaic of other vegetative components. Incomplete canopy closure.
Mature lodgepole pine	Mature lodgepole pine forest. Subalpine fir, spruce, and whitebark pine in understory.
High elevation grassland/ tundra[a]	Open vegetative component consisting of high elevation rocky grasslands, grasslands and meadows, and tundra.
Meadow mosaic	Wet and dry grass and forb meadows in a mosaic of other vegetative components. Includes seeps and nonforested openings. Open habitat.
Rock	Cliff, talus slides, and exposed bedrock. Soils are shallow and vegetation is sparse or restricted to the margins.
Other	Standing water, aspen, and minor vegetative components.

[a]Excluded from grizzly bear cover type use-availability analysis; consolidated into "other" cover type category.

To assess the use of forested cover by grizzly and black bears, I consolidated existing cover types into 3 categories: open habitat and nonforested areas, forested and open cover type vegetative mosaics, and forested habitat. I pooled all bear activity locations collected by

Reinhart and myself and tested for goodness-of-fit among the three cover type categories. I then separately tested the goodness-of-fit for positively identified grizzly and black bear activity sites, recorded by Reinhart and myself, across all years (unknown bear activity sites were excluded). The analysis was specific to the 250 m buffered transect area. Use versus availability analysis followed procedures described by Neu et al. (1974). Statistical significance was accepted at $P < 0.05$.

Food Habits

All bear scats located in 1990 and 1991 by Reinhart and all scats that I recorded in 1996 and 1997 were collected for diet composition analysis. Collected scats were identified according to transect location, estimated age, date collected, fecal diameter measurement, and possible species identification. Scats were air-dried approximately 1 week and stored in paper bags. The total number of scats collected each year varied due to survey intensity, weather conditions, and bear activity. Kevin Frey of Montana Fish, Wildlife, and Parks (MFWP) conducted the fecal analysis. Scats were rehydrated, broken apart, and washed through different diameter sieves for content identification and visual volume estimates (Mattson et al. 1991, Litvaitis et al. 1994, Kevin Frey, MFWP, pers. comm.). Scat contents were routinely identified to the finest taxonomic level possible. Scat content was summarized into eight major diet categories: whitebark pine seeds, fleshy fruits (berries), sporophytes, grasses/sedges, forbs, insects, miscellaneous (debris), and animal matter. Diet components were summarized by frequency of occurrence and percent fecal volume by season (spring, summer, and fall) (Mattson et al. 1991, Mattson and Reinhart 1992). Season definitions are described in the IGBST 1997 Yellowstone grizzly bear investigations annual report (Haroldson et al. 1997). Percent scat volume was averaged across all years and for aggregated years (Netter et al. 1993) giving each year's data equal weight.

I examined patterns of use by individual seasons, by species of bear, and across all years by season to determine the impacts of the temporal scale on interpretation of food habits. I summarized each diet item by its frequency of occurrence and percent fecal volume by year and season. I pooled Reinhart's data and the information I collected and analyzed the frequency of occurrence of the major diet items across all years by season. I also separately analyzed grizzly and black bear scat content collected by Reinhart and myself across all years by season because of sample size limitations (unknown species of bear scat were excluded). I used contingency table analysis to test for changes in use of the eight diet item categories among years (1990 versus 1991 versus 1996 versus 1997) and between bear species. Statistical significance was accepted at $P < 0.05$.

Core Area and Road Density Analysis

Road density analysis and "core" area estimates were conducted using moving windows analysis (Turner and Gardner 1990) in conjunction with the cumulative effects model (CEM) (USDA 1990). The disturbance submodel of the CEM quantifies the cumulative effects of disturbances associated with humans on grizzly bear habitat use (USDA 1990). The CEM uses four variables to stratify human activities: the type of activity, nature of activity, length of activity, and intensity of activity (USDA 1990). The cumulative effects of these four variables creates a "zone of influence" or buffered area around the human activity or disturbance, which represents the distance in which grizzly bears would likely be affected (USDA 1990). The buffered area represents "non-core" or sub-optimal bear habitat.

Existing road densities were categorized as either $\leq$ 1610 m/1610 m^2 ($\leq$ 1.0 mi/mi^2) or $\geq$ 1710 m/1610m^2 ($\geq$ 1.1 mi/mi^2) (J. T. Stangl, GNF, pers. comm.) based on Ruediger and Mealey's (1978) conclusion that road densities should not exceed 1610 m/1610 m^2 to provide adequate security for bears. Road density estimates included restricted and open roads, as defined by the Interagency Grizzly Bear Committee (IGBC) Taskforce Report (1998). The CEM quantifies road densities for two temporal periods (season 1 and season 2) to account for seasonal road restrictions or limited access. Season 1 ran from March 1 through July 15, and season 2 began July 16 and ended November 30.

Road densities were calculated for the 250 m buffered area around each transect. The area in each road density category was calculated as well. Season 1 and season 2 results were combined and analyzed together due to the lack of difference in road density between the two seasons. All bear activity site locations recorded by Reinhart and myself were pooled and tested for goodness-of-fit. Positively identified grizzly and black bear activity sites recorded by Reinhart and myself were pooled separately and also tested for goodness-of-fit across all years. Procedures described by Neu et al. (1974) were used to assess bear use versus availability of the two road density categories. Statistical significance was accepted at $P < 0.05$.

In conjunction with road density analysis, I calculated "core" and "non-core" area to account for the different levels of human activity and disturbance associated with roads and developments within the study area. The IGBC Taskforce Report (1998) defines a "core" area as having no motorized traffic and low levels of human use. I calculated "core" area associated with each transect based on human activity, road density, and road restrictions/access. Season 1 and season 2 classifications were used to account for annual changes in human use patterns and road accessibility. All habitat with roads and trails open to motorized vehicles and areas with roads and trails that received high intensity non-motorized use were excluded from my "core" area estimates (IGBC 1998). I defined high intensity use as 20 or more human parties per week or areas with concentrated activities (i.e. hunting) (USDA 1990, IGBC 1998). I defined "non-core" habitat as areas within 500 m of open roads and trails that allowed motorized use or areas that experienced high intense human use (Mattson et al. 1987, IGBC 1998).

"Core" and "non-core" area estimates were calculated for the 250 m buffered area associated with each transect. Season 1 and season 2 "core" and "non-core" area estimates were analyzed separately because seasonal road closures or accessibility differed between seasons 1 and 2. I pooled all bear activity sites recorded by Reinhart and myself and tested for goodness-of-fit. I then separately tested for the goodness-of-fit between black bear and grizzly bear use of "core" and "non-core" habitat across all years. Procedures described by Neu et al. (1974) were used to test bear's use of "core" and "non-core" habitat. Statistical significance was accepted at $P < 0.05$.

RESULTS

Density of Bear Activity

The density of bear activity varied among the 8 subunits and among years (Fig. 3). During 1990, the Mud Lake and Fisher Creek subunits had the highest density of bear activity (0.84 and 0.78 activity sites/km, respectively). The Woody Creek and Cooke Face subunits had the lowest density of bear activity (0.14 and 0.09 sites/km, respectively). In contrast, the Woody Creek subunit had the highest density of recorded bear activity (0.42 sites/km) the following year. The density of bear activity recorded in the Miller Creek, Fisher Creek, Stillwater, Republic Creek and Sheep Creek subunits ranged from 0.23 to 0.37 sites/km, respectively during 1991. The Mud Lake and Cooke Face subunits had the lowest density of recorded bear activity (0.18 and 0.09 sites/km) among the eight subunits.

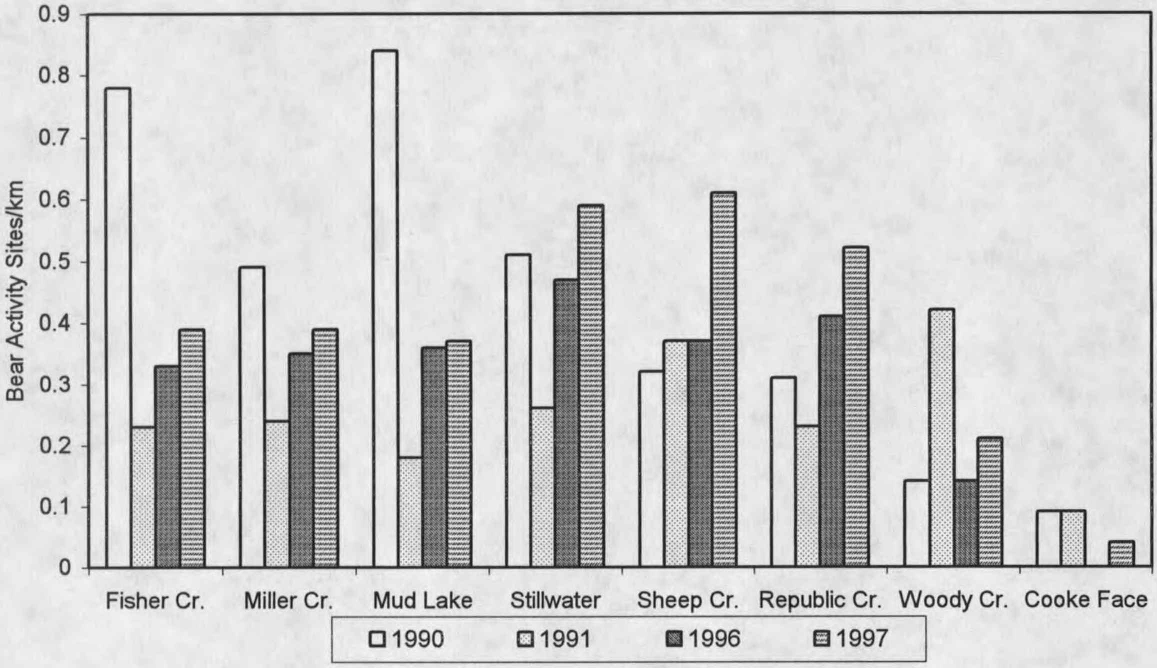

Figure 3. The density of bear activity recorded along repeated transect routes with in the 8 study area subunits during 1990, 1991, 1996, and 1997. The Cooke Face was not sampled during 1996.

The density of bear activity recorded in 1996 was highest in the Stillwater and Republic Creek subunits (0.47 and 0.43 bear sites/km, respectively) (Fig. 3; Appendix B, Table 9). The density of bear activity recorded in the Fisher Creek, Miller Creek, Mud Lake, and Sheep Creek subunits ranged from 0.33 to 0.37 sites/km. Similar to 1990, the Woody Creek subunit had the lowest density of bear activity (0.14 sites/km) among the 8 subunits. The Cooke Face subunit was not sampled. During 1997, the Sheep Creek subunit had the highest density of recorded bear activity (0.61 sites/km). Consistent with 1990 and 1991 results, the Cooke Face subunit had the lowest density of bear activity of (0.04 sites/km) during 1997 (Fig. 3; Appendix B, Table 10).

Although the differences in density of bear activity recorded during aggregated sample periods (1990-1991 versus 1996-1997) was statistically insignificant ($T = 16$, $n = 8$, $P = 0.221$) among the 8 subunits, the ranking of subunits changed between the two periods. The Fisher Creek and Mud Lake subunits had the highest densities of bear activity (0.50 and 0.48 sites/km, respectively) during the 1990-1991 period. In contrast, the Stillwater, Sheep Creek, and Republic Creek subunits had the highest densities of bear activity (0.52, 0.47, and 0.47 sites/km) during the 1996-1997 period (Fig. 4, Fig. 6). During 1990-1991 and 1996-1997, the Miller Creek and Woody Creek subunits had intermediate densities of bear activity. The Cooke Face subunit had the lowest density of bear activity (0.09 and 0.04 sites/km for 1990-1991 and 1996-1997, respectively) for both periods.

The density of recorded bear activity in the eight subunits during "good" pine nut years (1991/1996) and "poor" pine nut years (1990/1997) was also statistically insignificant ($T = 4$, $n = 8$, $P = 0.500$). During "poor" years, the Stillwater, Fisher Creek, and Mud Lake subunits had the highest density of recorded bear activity (0.79, 0.60, and 0.59 sites/km, respectively). In contrast, the Sheep Creek, Stillwater, and Republic Creek subunits had the highest density of recorded bear activity (0.37, 0.35 and 0.31 sites/km, respectively) during "good" years. The lowest density of recorded bear activity occurred in the Woody Creek and Cooke Face subunits (0.18 and 0.09

sites/km) during "poor" years. Similarly, the Cooke Face subunit had the lowest density of bear activity (0.09 sites/km) during "good" years.

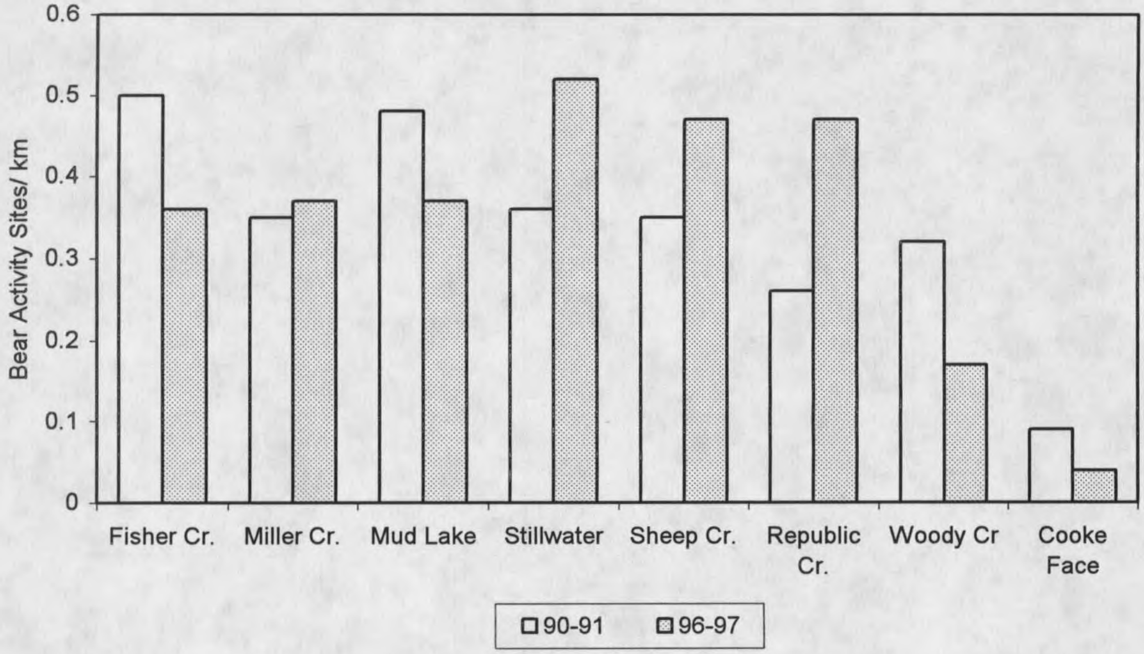

Figure 4. The density of all bear activity recorded along repeated transect routes within the 8 study area subunits during the combined 1990-1991 and 1996-1997 periods.

There was a significant difference in the recorded density of bear activity among the 8 subunits, across all years ($H = 35.17$, 7 df, $P < 0.001$). The densities of bear activity recorded in the Fisher Creek, Miller Creek, Sheep Creek, Mud Lake, Stillwater, and Republic Creek subunits were similar (Fig. 5, Fig. 7). The Woody Creek subunit had a lower density of bear activity than the previous subunits, but was much greater than the Cooke Face subunit. The density of bear activity recorded in the Cooke Face subunit was significantly lower than all subunits. The Fisher Creek and Stillwater subunits had the highest density of recorded bear activity (0.43 sites/km) across all years (Fig. 5). The Miller Creek, Sheep Creek, Republic Creek, Woody Creek, and Mud Lake subunits had intermediate densities of bear activity (0.24 to 0.42 sites/km, respectively). The lowest density of recorded bear activity (0.07 sites/km) occurred in the Cooke Face subunit (Fig. 5, Fig. 7).

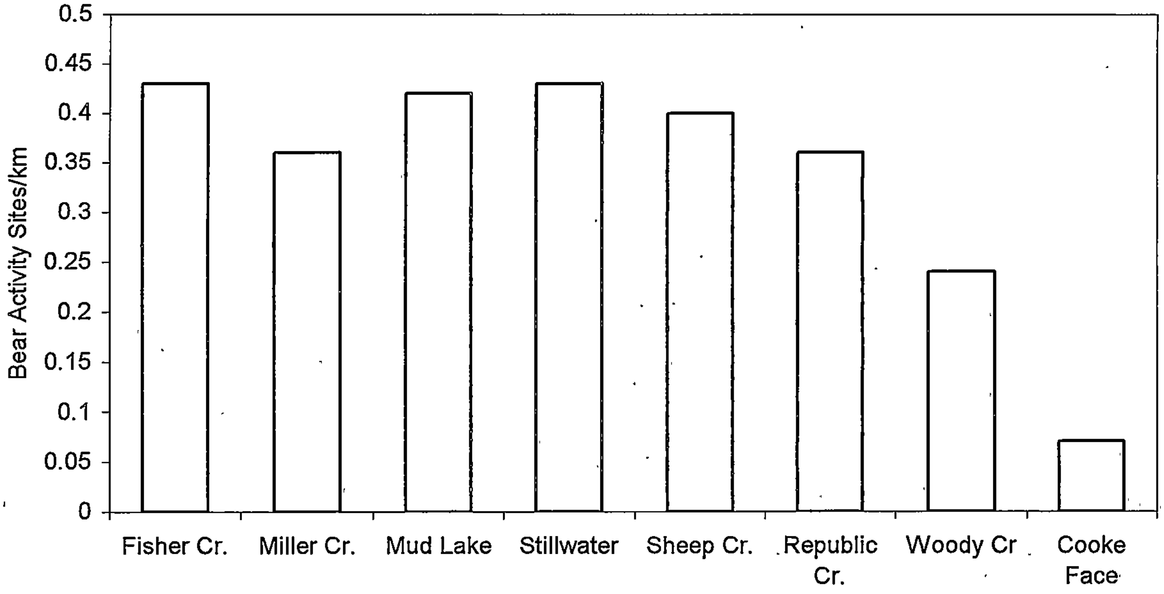

Figure 5. The density of all bear activity recorded along repeated transect routes within the 8 study area subunits, across all years.

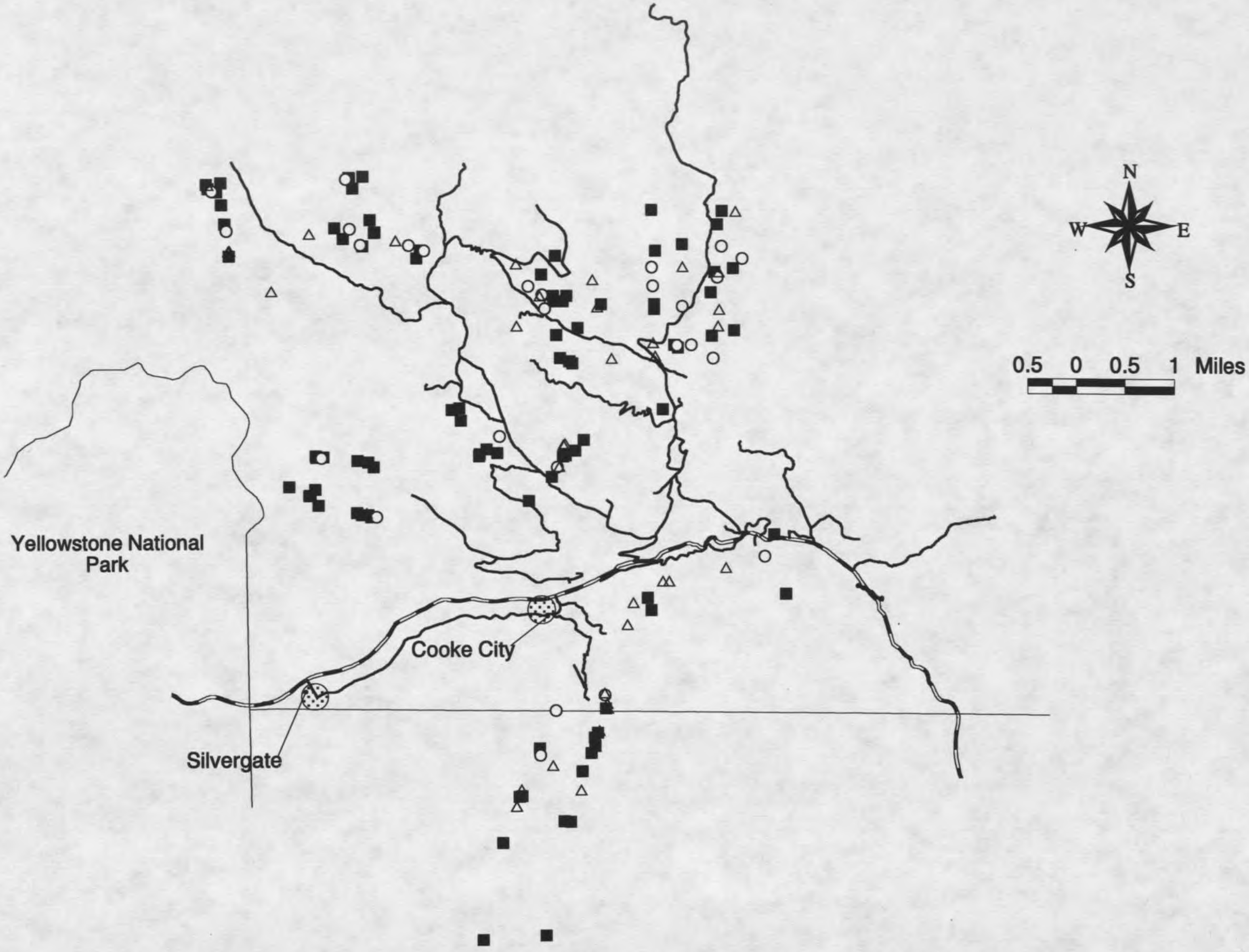

Figure 6. Locations of bear activity points recorded in 1996 and 1997. Solid boxes indicate grizzly bear activity, white circles indicate black bear activity, and open triangles indicate activity of unknown bear species.

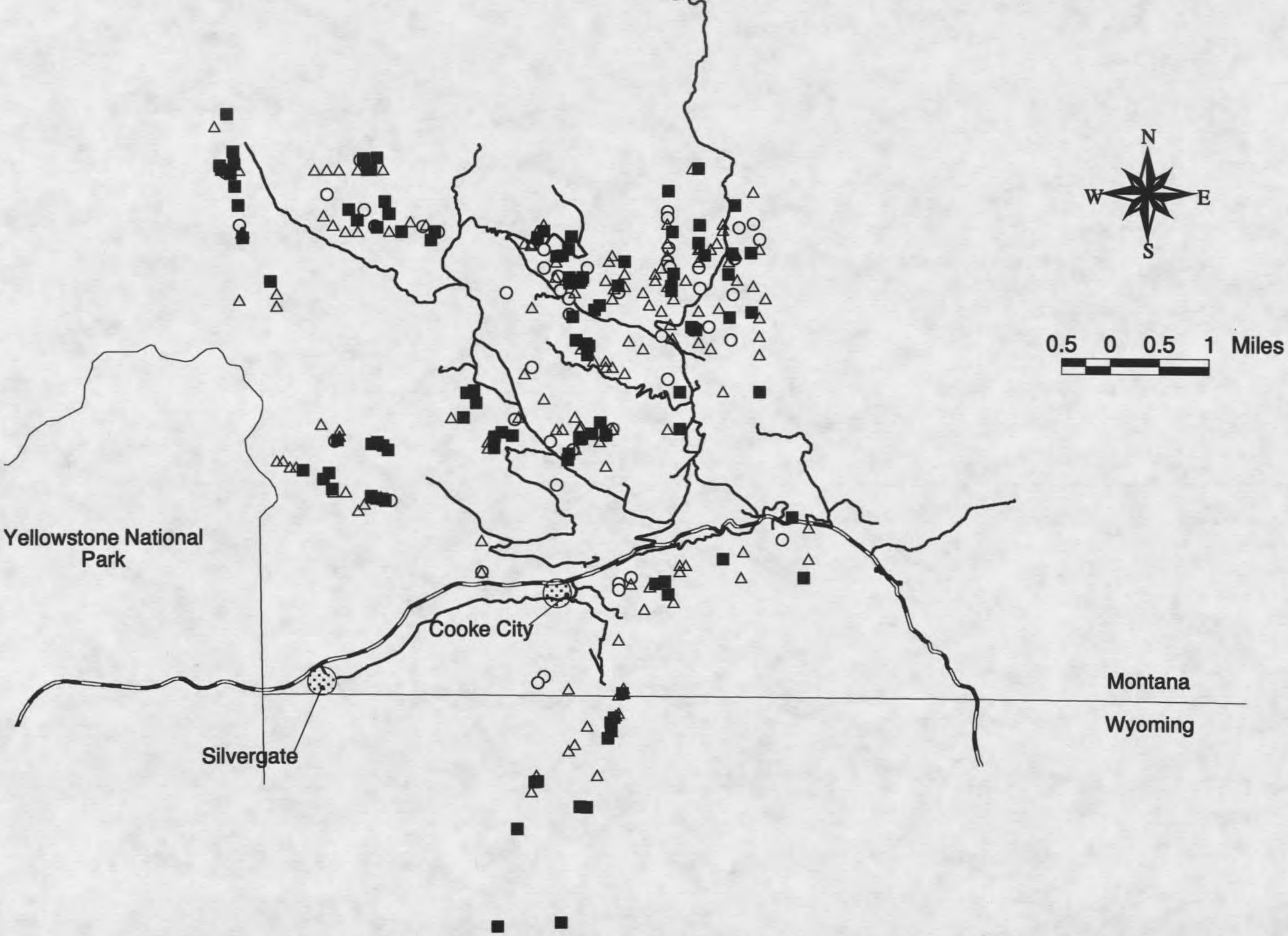

Figure 7. Locations of bear activity points recorded on repeated transects during 1990, 1991, 1996, and 1997. Solid boxes indicate grizzly bear activity, white circles indicate black bear activity, and open triangles indicate activity of unknown bear species.

Cover Type Use-Availability Analysis

The distribution of all bear activity (grizzly and black bear) among the 10 cover types, across all years, was statistically different ($X^2 = 104.80$, 9 df, $P < 0.001$). The mature whitebark pine and mature whitebark pine mosaic cover types were used disproportionately more than expected by all bears. Habitat utilized less than expected included the mature subalpine fir mosaic, rock, and "other" cover types. The remaining cover types were used in proportion to their availability (Fig. 8; Appendix C, Table 11).

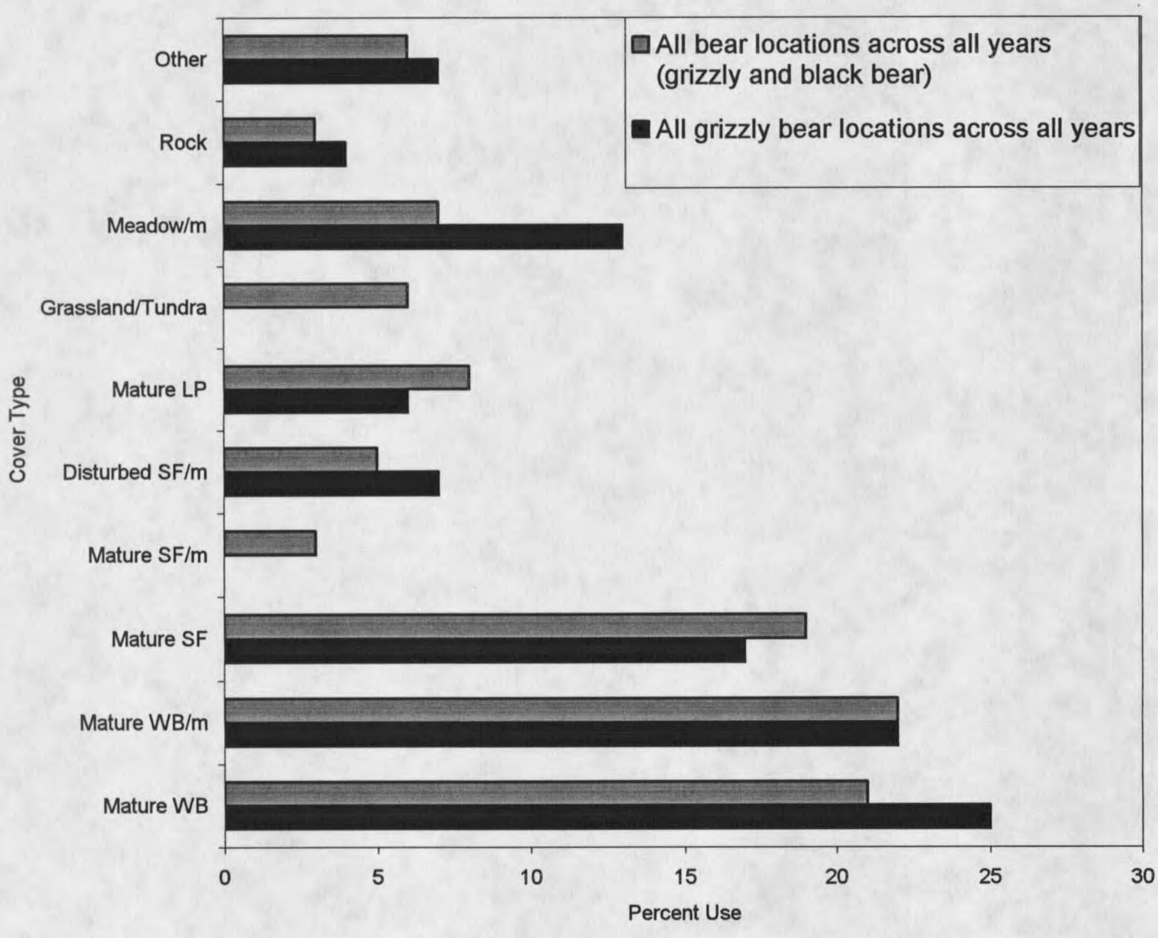

Figure 8. All bear and grizzly bear cover type use across all years. Abbreviations above indicate whitebark pine (WB), subalpine fir (SF), lodgepole pine (LP), and vegetative mosaic (m). The mature SF mosaic and grassland/tundra cover types were not included in the grizzly bear cover type use analysis. Black bear cover type use analysis was not conducted due to the lack of a sufficient sample size.

When only known grizzly bear sign was considered and data from all years was included, cover type use differed from availability ($X^2 = 72.85$, 7 df, $P < 0.001$). Grizzly bear locations ($n = 134$) occurred more than expected in the mature whitebark pine cover type (Appendix C, Table 12). The "other" cover type category was used less than expected by grizzly bears. The remaining cover types were used as expected by grizzly bears across all years (Fig. 8).

When I examined cover type use versus availability for individual time periods, I found disproportionate use of cover types during the 1990-1991 period ($X^2 = 49.03$, 9 df, $P < 0.001$) and the 1996-1997 period ($X^2 = 81.03$, 9 df, $P < 0.001$) (Appendix C, Tables 13 and 14). During both sample periods, all bear sign was recorded in the mature whitebark pine cover type significantly more than expected. During the 1990-1991 period, all bear sign was also recorded disproportionately more than expected in the mature whitebark pine mosaic and disturbed subalpine fir mosaic. Vegetative components used less than expected during the 1996-1997 period included the mature lodgepole pine, grassland/tundra, and rock cover types. The "other" cover type category was used less than expected during both the 1990-1991 and 1996-1997 periods. The remaining cover types were used in proportion to their availability during both periods (Fig. 9; Appendix C, Tables 13 and 14).

When I analyzed cover type use versus availability related to whitebark pine cone production, I found disproportionate use of cover types, among all bears, during years of "poor" [1990/1997 ($X^2 = 71.35$ 9 df, $P < 0.001$)] and "good" [1991/1996 ($X^2 = 47.41$, 9 df, $P < 0.001$)] whitebark pine cone crops (Appendix C, Tables 15 and 16). The mature whitebark pine cover type was used significantly more than expected during both "good" and "poor" years. The mature whitebark pine mosaic was also used disproportionately more than expected during "poor" years of whitebark pine cone production. Cover types used less than expected during the 1990/1997 period include the mature subalpine fir mosaic, mature lodgepole pine, and the "other" cover type category. The "other" cover type category was also used less than expected during the 1991/1996 period. The remaining cover types were used in proportion to their availability during both "poor" and "good" years of whitebark pine cone production (Fig. 9; Appendix C, Tables 15 and 16).

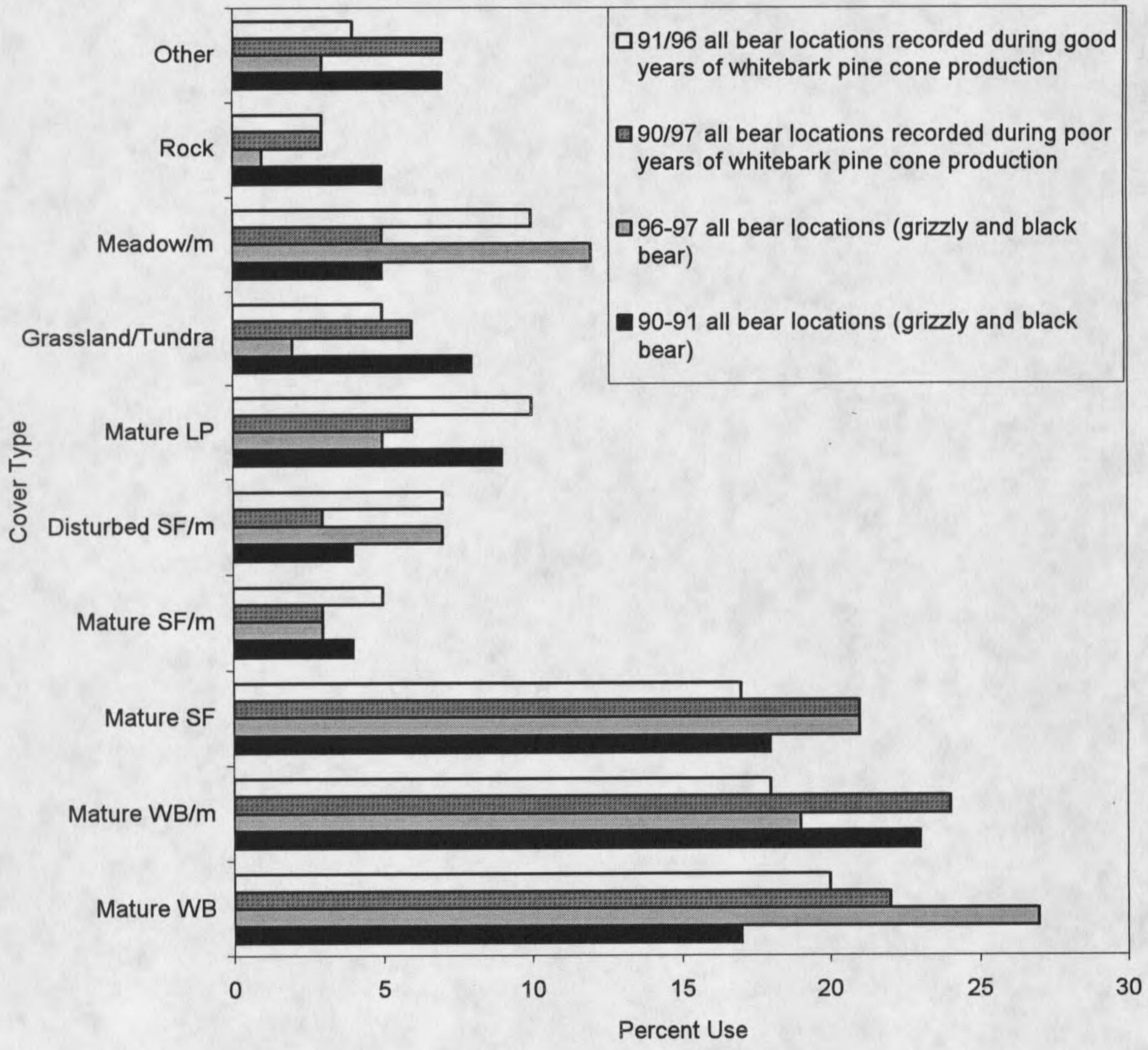

Figure 9. All bear (grizzly and black bear) cover type use among aggregated time periods. Abbreviations above indicate whitebark pine (WB), subalpine fir (SF), lodgepole pine (LP), and vegetative mosaic (m). Years of "poor" whitebark pine cone production were defined as years when cones averaged < 13 cones per tree on IGBST permanent transects. Years of "good" whitebark pine cone production were defined as years when cones averaged ≥ 13 cones per tree on IGBST permanent transects.

When I collapsed the ten cover types into three categories based solely on forest density, there was a significant difference in use versus availability among all bear activity (grizzly and black bear) (n = 382), across all years, within open, forested/open mosaics, and forested cover types ($X^2 = 33.88$, 2 df, $P < 0.001$). All bear activity was recorded less than expected in open cover types, while both the forested/open mosaic and forested cover types had disproportionately more bear activity (Appendix C, Table 17). The open cover type encompassed 30% of the buffered transect area. Forested and forested/open mosaic cover types covered approximately 45% and 25% of the buffered transect area, respectively.

When I examined use versus availability for individual bear species, I found disproportionate use of cover types by grizzly bears (n = 134; $X^2 = 17.89$, 2 df, $P < 0.001$) and black bears (n = 61; $X^2 = 6.57$, 2 df, $P = 0.0375$) among open, forested/open mosaics, and forested cover types. Open habitat was used less than expected by both grizzly and black bears, while forested/open mosaics and forested cover types were used in proportion to their availability (Appendix C, Tables 18 and 19).

I used a 2-acre polygon resolution vegetation map to quantify cover types. The map scale hid the importance of habitat microsites found throughout the forest matrix. Approximately 49% in 1996 and 57% in 1997 of bear activity sites were associated with habitat microsites (mosaics/ecotones). Grass and forb meadows were associated with 33% and 27% of the 1996 and 1997 bear activity sites, respectively. The most frequent habitat microsite consisted of a forested cover type adjacent to a forb-dominated meadow.

Food Habits

Across all years, 428 bear scats were analyzed: 133 from 1990, 127 from 1991, 90 from 1996, and 78 from 1997. TLC resulted in the positive identification of 201 grizzly bear scats and

71 black bear scats. One hundred and fifty six bear scats were of unknown origin. Thirty-seven different diet items were identified to the genus and/or species level (Table 3).

Table 3. Plant and animal material identified in bear scats across all years.

Pinus albicalus seeds – Whitebark pine	**Forbs**
Fleshy fruits (Berries)	*Agoseris* sp. – False dandelion
Amelanchier sp. – Service berry	*Angelica* sp. – Angelica
Ribes sp. – Goose berry	*Astragalus* sp. – Milk vetch
Shepherdia canadensis – Buffalo berry	*Cirsium* sp. – Thistle
Symphoricarpos albus – Snowberry	*Epilobium* sp. – Fireweed
Vaccinium scoparium – Grouse whortleberry	*Fragaria* sp. – Strawberry
Grasses/Sedges	*Heracleum* sp. – Parsnip
Agropyron sp. – Wheatgrass	*Lathyrus* sp. – Wild pea
Bromus sp. – Brome grass	*Ligusticum* sp. – Licorice root
Carex sp. - Sedge	*Lomatium* sp. – Biscuitroot
Deschampsia sp. – Hairgrass	*Osmorhiza* sp. – Sweet cicely
Juncus sp. – Rush	*Perideridia* sp. - Yampa
Phleum sp. – Timothy	*Stellaria longipes* – Chichweed
Poa sp. – Poa	*Taraxacum* sp. – Dandelion
Unidentified grass/sedge (other)	*Tragopogon* sp. – Salsify
Sporophytes	*Trifolium* sp. – Clover
Equisetum sp. – Horsetail	Unidentified forb (other)
Lycopodium sp. – Club moss	**Animal matter**
Insects	*Alces alces* – Moose
Ants	Cervidae – Deer and elk
Maggots	*Cervas elaphus* – Elk
Tetraonidae	*Odocoileus hemionus* – Mule deer
Unidentified insect parts (other)	*Tamiasiciurus hudsonicus* – Red squirrel
Miscellaneous	*Thomomys talpoides* – Northern pocket gopher
Debris	Ursidae sp. – Bear
Pine needles	Unidentified bird
Unidentified root	

Seasonal Food Habits Across All Years for All Bears

The four-year seasonal food habits analysis includes grizzly bear, black bear, and unknown scats. General diet patterns were evident, although they cannot be attributed to one species or the other. Annual variation in diet is partially masked due to the pooled bear scats across all four years.

Whitebark pine seeds were most readily available and consumed during spring and fall. Whitebark pine seeds were evident in 81% of 51 spring scats, 30% of 268 summer scats, and 45%

of 109 fall scats, respectively. Whitebark pine seeds constituted 70% of the spring fecal matter and 23% of fall fecal matter (Table 4).

Table 4. The frequency of occurrence and percent fecal volume of the 8 diet items evident in all bear scats (grizzly and black bear), collected across all years, equally weighted by season.

	Spring n = 51		Summer n= 268		Fall n = 109	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark	80.8	70.4	30.2	13.6	45.0	23.7
Fleshy Fruits	3.9	0.1	17.5	0.9	25.7	9.5
Sporophyte	3.9	1.0	7.1	0.1	3.7	0.1
Grass/Sedge	43.1	1.8	56.3	4.2	43.1	2.5
Forbs	13.7	1.6	72.8	8.5	47.7	3.6
Insect	17.7	0.5	19.8	0.4	8.3	T
Debris	33.3	5.3	24.6	1.9	14.7	0.1
Animal	5.9	0.2	10.1	0.1	16.5	0.3

Trace (less than 0.1)

Herbaceous material dominated summer scats, the season when diet diversity was greatest. Grasses/sedges were common bear scat components during all seasons, with peak occurrence during summer months. Approximately 56% of summer scats and 43% of spring and fall scats contained evidence of grasses/sedges. *Poa* sp. and *Carex* sp. were the two most commonly identified grass/sedge genera in all bear scats (Appendix D, Table 20).

Forbs were found in 73% of summer scats, the most of any season (Table 4). The occurrence of forbs in scats was lowest in spring, evident in 14% of the scats, while moderate in fall. The most frequently identified forbs in summer and fall scats were *Epilobium* sp. and *Taraxacum* sp. (Appendix D, Table 20).

The frequency of occurrence of fleshy fruits in scats peaked during fall, occurring in 26% of scats and constituting 10% of the fecal volume. Frequency of occurrence was lowest in spring scats (4%), while approximately 18% of summer scats contained evidence of fleshy fruits (Table 4). *Vaccinium scoparium* was the most common berry-producing shrub evident in bear scats across all years. Other berry producing shrubs identified in scats included *Amelanchier* sp., *Ribes* sp., *Shepherdia canadensis*, and *Symphorocarpos albus*.

Animal matter was most common in bear scats during fall months across all years. Elk was the most frequent ungulate in fall scats, evident in approximately 8% of 109 scats. Red squirrel and bear meat and hair were found in 4% and 3% of all fall scats, respectively. The greatest diversity of animal matter occurred in summer scats but only in trace amounts (Appendix D, Table 20). Insect use peaked in spring and summer, occurring in 18% and 20% of all scats, respectively (Table 4). The majority of insect matter could only be identified as "ant".

The frequency of occurrence of sporophytes peaked during summer months, but overall, was a minor scat component. E*quisetum* sp. was most common during summer, occurring in 6% of 268 scats. *Lycopodium* sp. was a minor scat component in summer and fall scats and was not evident is spring fecal matter.

Seasonal Food Habits Across all Years by Bear Species

The greatest occurrence of whitebark pine seeds in grizzly bear scats occurred in spring and fall, across all years. Whitebark pine seeds were evident in 88% of 26 spring scats and approximately 49% of 67 fall scats. Percent scat volume ranged from a high of 86% in spring to a low of 3% in summer (Table 5).

Table 5. The frequency of occurrence and percent fecal volume of the 8 diet items evident in grizzly bear scats, collected across all years, equally weighted by season.

	Spring n=26		Summer n=108		Fall n=67	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark	88.5	86.2	18.5	2.9	49.3	27.6
Fleshy Fruits	0	0	13.0	2.5	9.0	0.1
Sporophyte	7.7	5.0	6.5	0.2	7.5	0.1
Grass/Sedge	26.9	1.3	51.9	3.8	38.8	2.6
Forbs	7.7	1.0	80.6	11.3	59.7	5.9
Insect	7.7	T	24.1	1.3	11.9	T
Debris	11.5	2.9	26.9	2.8	9.0	0.3
Animal	3.9	0.8	7.4	0.2	17.9	0.3

Trace (less than 0.1)

The frequency of grasses/sedges peaked in summer months, occurring in 52% of all grizzly scats. Moderate use of grasses/sedges occurred in both spring and fall. The two most common grass/sedge genera recorded in summer and fall grizzly scats were *Carex* sp. and *Poa sp. Deschampsia* sp. and *Poa* sp. both occurred in 4% of spring scats, while *Carex* sp. was evident in 8% of all spring scats (Appendix D, Table 21).

Forbs were a dominant summer and fall grizzly bear scat component. Approximately 81% of 108 summer scats had evidence of forbs, and forbs made up 11% of the fecal matter. Roughly 60% of all fall scats contained forbs. *Epilobium* sp. and *Taraxacum* sp. were the two most commonly identified forb genera in both summer and fall grizzly scats. *Cirsium* sp., *Ozmorhiza* sp., and *Trifolium* sp. were minor grizzly bear summer and fall scat components.

The presence of fleshy fruits peaked during summer months when they occurred in 13% of all grizzly bear scats. Nine percent of all fall scats contained fleshy fruits. Spring scats were completely void of berry producing shrub matter. *Vaccinium scoparium* was the most common fleshy fruit identified in grizzly bear scats. Other berry producing shrubs identifed in summer and fall grizzly scats included *Ribes* sp., *Shepherdia canadensis*, and *Symphoricarpos albus.*

Animal matter was most common in fall grizzly scats (Table 5). Elk (meat and hair) was the dominant ungulate component in scats during fall (evident in 7% of all scats) but contributed an insignificant amount to the overall fecal volume. Red squirrel and bear matter (hair and meat) was evident in 4% of all fall scats. Animal matter constituted a minor portion of percent volume across all seasons (Appendix D, Table 21). Insect components were most common in summer, when they occurred in 24% of all summer grizzly scats. Ants and maggots were the two most commonly recognized insect items in all grizzly bear scats across all years. Twelve percent of all fall scats and 8% of all spring scats contained insect matter.

Sporophytes (*Equisetum* sp.) were most common in spring and summer, evident in 8% and 6% of scats, respectively (Table 5). *Lycopodium* sp. was a minor scat component across all seasons. Debris occurred in 27% of all summer scats, 12% of spring scats, and 9% of fall scats.

The scat sample size for spring and fall black bear scats was limited, so I only reported summer diet patterns. The occurrence of grasses/sedges and forbs were most common in summer black bear scats, occurring in 78% and 69% of all scats, respectively (Table 6). Grasses/sedges and forbs comprised approximately 12% and 9% of the summer fecal matter. *Carex* sp., *Poa* sp., *Taraxacum* sp., *Ozmorhiza* sp., and *Trifolium* sp were the most commonly identified grass/sedge and forb genera in summer scats (Appendix D, Table 22). Both *Shepherdia canadensis* and *Vaccinium scoparium* were found in 6% of summer scats, but they occupied < 1% of fecal matter. Whitebark pine seeds were the third most common summer food item, comprising 12% of black bear fecal matter. Ungulates and insects occurred in 12% and 18% of the analyzed summer black bear scats. *Equisetum* sp. and debris were evident in 12% and 18% of the sampled black bear scats, respectively.

Table 6. The frequency of occurrence and percent fecal volume of the 8 diet items evident in black bear scats, collected across all years, equally weighted by season.

	Spring n=9		Summer n=51		Fall n=11	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark	77.8	42.7	27.5	12.2	54.6	24.2
Fleshy Fruits	11.1	0.2	11.8	0.2	18.2	3.5
Sporophyte	0	0	11.8	0.5	9.1	3.0
Grass/Sedge	44.4	5.7	78.4	12.2	81.8	5.3
Forbs	33.3	14.3	68.6	8.8	72.7	3.1
Insect	22.2	2.7	17.7	0.4	0	0
Debris	22.2	5.6	17.7	1.0	18.2	9.1
Animal	11.1	0.3	11.8	0.3	9.1	0.1

Black bear and grizzly bear scat content differed primarily with regard to grasses and sedges (Table 7). Roughly 73% of 71 black bear scats contained evidence of grasses/sedges. In contrast, approximately 43% of 201 grizzly bear scats contained grasses/sedges. The frequency of occurrence of all other diet items including whitebark pine, fleshy fruits, forbs, insects, sporophytes, and animal matter were similar in both species of bear.

Table 7. Contingency table statistical summary for the independent frequency of occurrence of the 7 food items identified in all black bear and grizzly bear scats, across all years, with all seasons combined.

	Black bear versus Grizzly bear	
Diet Item	X^2	**P-Value**
Whitebark	0.032	0.858
Fleshy Fruits	2.153	0.142
Sporophytes	0.886	0.347
Grass/Sedge	18.85	< 0.001
Forbs	0.044	0.834
Insects	0.214	0.644
Animal	0.688	0.407

Individual Year Scat Content

When bear scats (grizzly bear, black bear, and unknown bear scats) were analyzed by individual years, it became apparent that many patterns identified in the four years of cumulative data were an artifact of data pooling. Seasonal variations in bear food habits were evident among and between years. However differences may be an artifact of different proportions of grizzly bear and black bear scats, the annual variation between each sample year, or the scat sample size.

The high year-to-year variability in content of feces was reflected in statistical comparisons of the frequency of occurrence of seven of the eight diet items in bear scats (grizzly and black bear) among the four years (Table 8). Only the occurrence of sporophytes in bear scats did not differ between 1990, 1991, 1996, and 1997. The occurrence of whitebark pine seeds, fleshy fruits, grasses/sedges, forbs, insects, and animal matter were all dependent upon the sample year.

Whitebark pine dominated spring and summer scats of 1990, spring scats of 1997, and fall scats of 1991 (Figs. 10,13, and 11), but were rare in fall scats of 1990 and spring scats of 1991 (Figs. 10 and 11). Grasses/sedges and forbs were consistently evident in summer and fall scats of 1996 and 1997, spring and summer scats of 1991, and less evident in 1990 scats across all seasons. Fleshy fruits were a minor scat component except during the fall of 1990, when *Vaccinium scoparium* and other species accounted for 69% of the 1990 fall fecal volume. Sporophytes, mainly *Equisetum* sp., were also a minor scat component except during spring of 1991 in which they comprised 26% of the spring fecal matter. During the fall of 1996 debris was a major scat component, when it accounted for 58% of the fecal volume (Appendix D, Tables 23-26).

Table 8. Contingency table statistical summary for the independent frequency of occurrence of the 7 food items identified in all bear scats (black and grizzly bear) collected among years.

	1990 vs 1991 vs 1996 vs 1997	
Diet Item	**X^2**	**P-Value**
Whitebark	52.76	< 0.001
Fleshy Fruits	41.72	< 0.001
Sporophytes	4.66	0.198
Grass/Sedge	13.04	0.005
Forbs	84.03	< 0.001
Insects	10.75	0.013
Animal	11.73	0.008

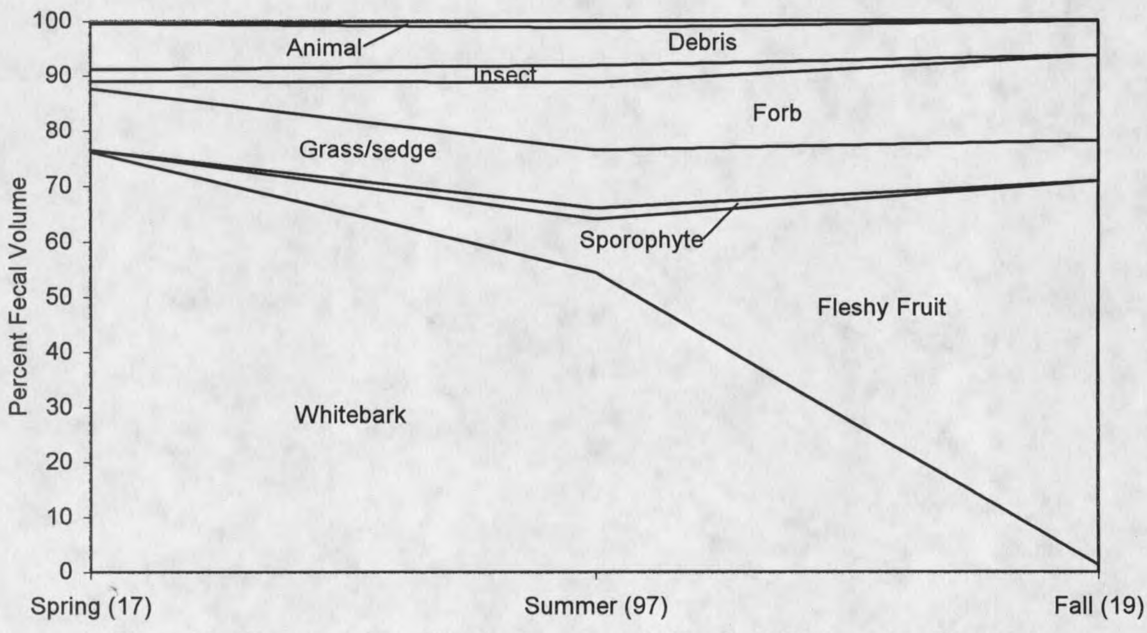

Figure 10. The proportion of fecal volume occupied by the 8 diet items in all bear scats collected during 1990. The number in parentheses indicates scat sample size.

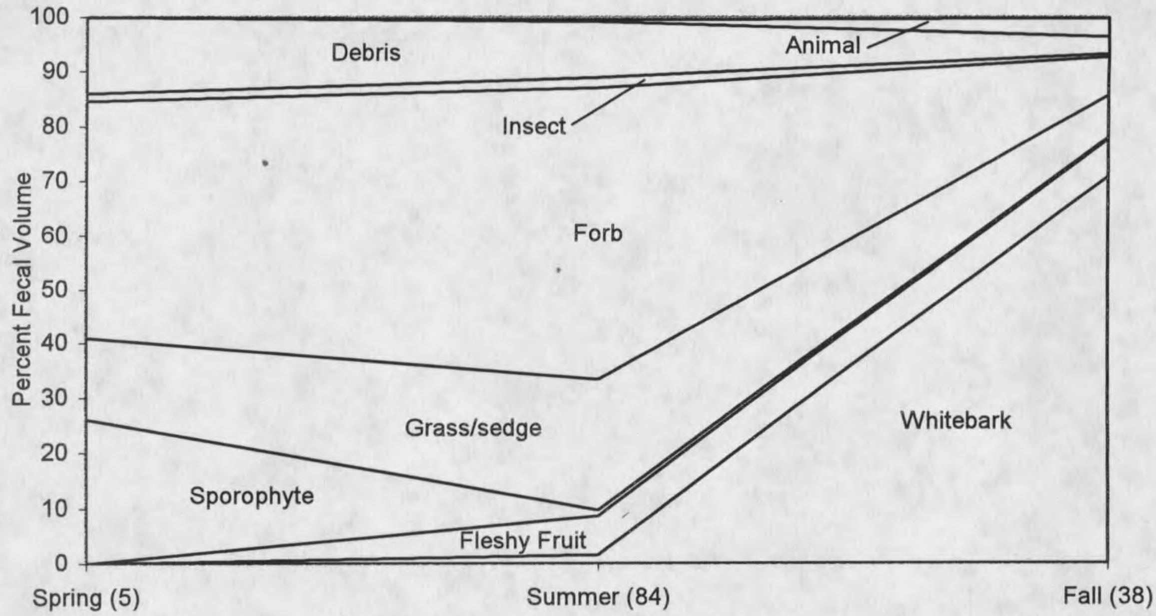

Figure 11. The proportion of fecal volume occupied by the 8 diet items in all bear scats collected during 1991. The number in parentheses indicates scat sample size.

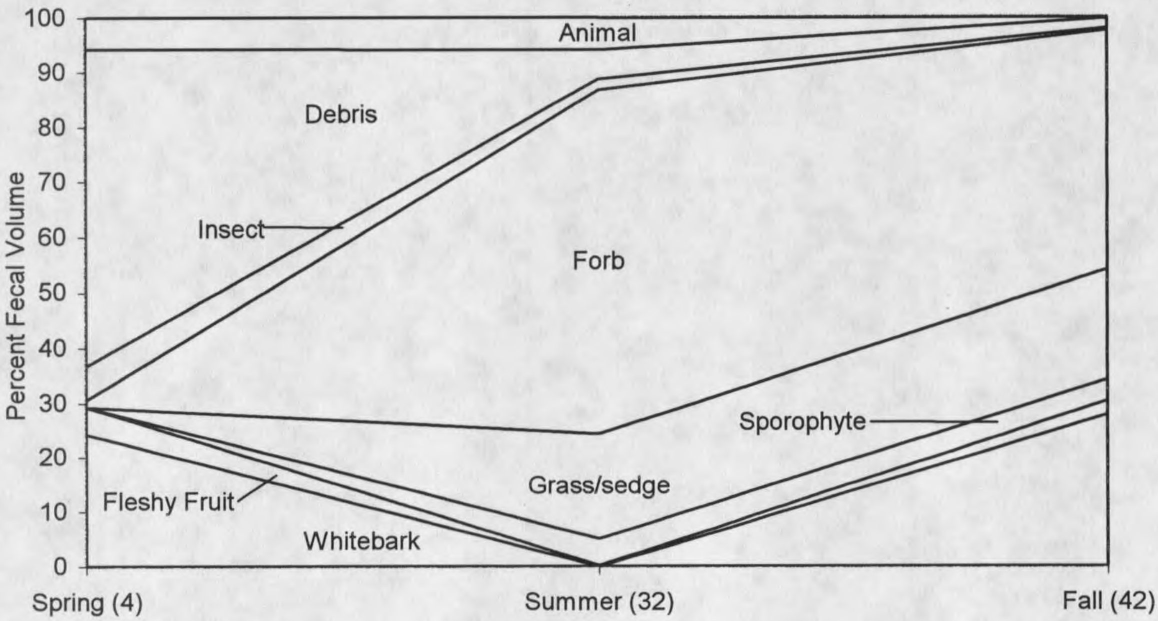

Figure 12. The proportion of fecal volume occupied by the 8 diet items in all bear scats collected during 1996. The number in parentheses indicates scat sample size.

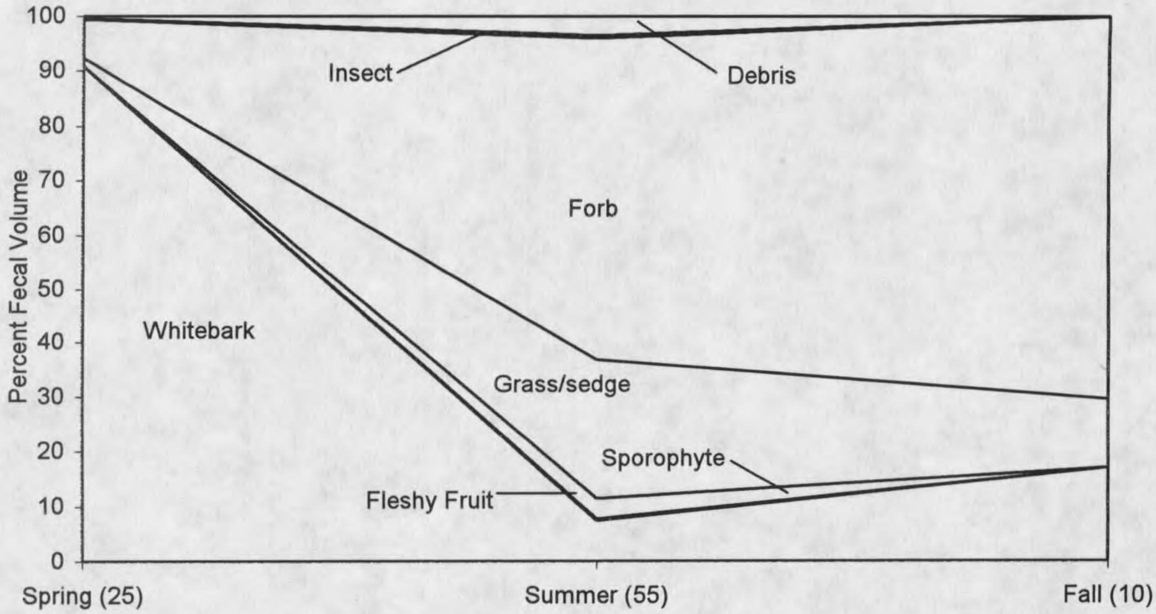

Figure 13. The proportion of fecal volume occupied by the 8 diet items in all bear scats collected during 1997. The number in parentheses indicates scat sample size.

Road Density and Core Area Analysis

The difference in distribution of all recorded bear activity locations (n = 382) between the two road density categories [≤ 1,610m/1,610m^2 (≤ 1.0 mi/mi^2) or ≥ 1,717m/1,610m^2 (≥ 1.1 mi/mi^2)] was statistically insignificant (X^2 = 2.817, 1 df, P = 0.093). Approximately 47% of the area within the buffered transect zone had a road density of ≤ 1,610m/1,610m^2. A total of 195 bear activity locations were recorded in this category. In contrast, 53% of the area within the buffered transects had a road density of ≥ 1,771m/1,610m^2, and had 187 recorded bear activity locations. The Miller Creek, Fisher Creek and Cooke Face subunits had road densities that exceeded 3,221/1,610m^2 (2.0mi/mi^2) (Fig. 14) due to the Miller and Fisher Creek county roads and the Highway 212 corridor. The area buffering the Lake Abundance road and Goose Lake jeep trail had a road density of 1,771m to 3,221m/1,610m^2. The Sheep Creek, Republic Creek, and the upper portion of the Woody Creek subunit had the lowest road densities of the eight subunits.

The distribution of data that I could unambiguously classify as grizzly bear activity sites (n = 134) differed between high and low road density areas (X^2 = 4.390, 1 df, P = 0.036). Roaded areas with ≤ 1,610m/1,610m^2 were used more than expected by grizzlies (n = 72), while areas with ≥ 1,771m/1,610m^2 were used less than expected (n = 62). The distribution of black bear activity sites (n =61) did not differ between high and low road density areas (X^2 = 0.381, 1 df, P = 0.537).

In my study area "core" and "non-core" habitat was heavily influenced by road distribution. The majority of the area was designated as "non-core" habitat (Fig. 15) because of proximity to roads and human developments. "Core" area varied with the seasonally accessible road system. During season 1, the Sheep Creek, Stillwater, Republic Creek, and upper portions of the Woody Creek subunit had significant amounts of "core" area. During season 2, the amount of "core" area was reduced in the Stillwater subunit due to the summer and fall Lake Abundance road access (Fig. 15). Subunits with consistent amounts of "non-core" habitat for both seasons 1 and 2 included the Fisher Creek, Miller Creek, Mud Lake, Cooke Face, and the lower portion of the Woody Creek subunit.

The difference in distribution of all bear activity (n = 382) between "core" and "non-core" habitat within the buffered transect area was statistically insignificant for season 1(X^2 = 0.003, 1 df, P = 0.957) and season 2 (X^2 = 1.133, 1 df, P = 0.287). "Core" and "non-core" habitat for season 1 accounted for 44% and 56% of the buffered transect area, respectively. In season 1, a total of 168 bear activity sites were recorded in core habitat and 214 in non-core habitat (Fig. 15). During season 2, approximately 35% and 66% of the buffered transect area was deemed "core" and "non-core" habitat. A total of 145 and 237 bear activity sites were recorded in "core" and "non-core" habitat, respectively (Fig. 15).

The distribution of grizzly bear locations in "core" (n = 64 in season 1; n = 56 in season 2) and "non-core" (n = 70 in season 1; n = 78 in season 2) habitat was proportionate to availability for both season 1 ($X^2 = 0.836$, 1 df, $P = 0.361$) and season 2 ($X^2 = 2.429$, 1 df, $P = 0.119$). In contrast, there was a significant difference ($X^2 = 5.091$, 1 df, $P = 0.024$) in the distribution of black bear activity locations with regard to "core" ($n = 18$) and "non-core" ($n = 43$) habitat during season 1. Black bear activity was found disproportionately less than expected in "core" habitat and more than expected in "non-core" habitat. The distribution of black bear activity in "core" and "non-core" habitat during season 2 was insignificant ($X^2 = 2.222$, 1 df, $P = 0.136$).

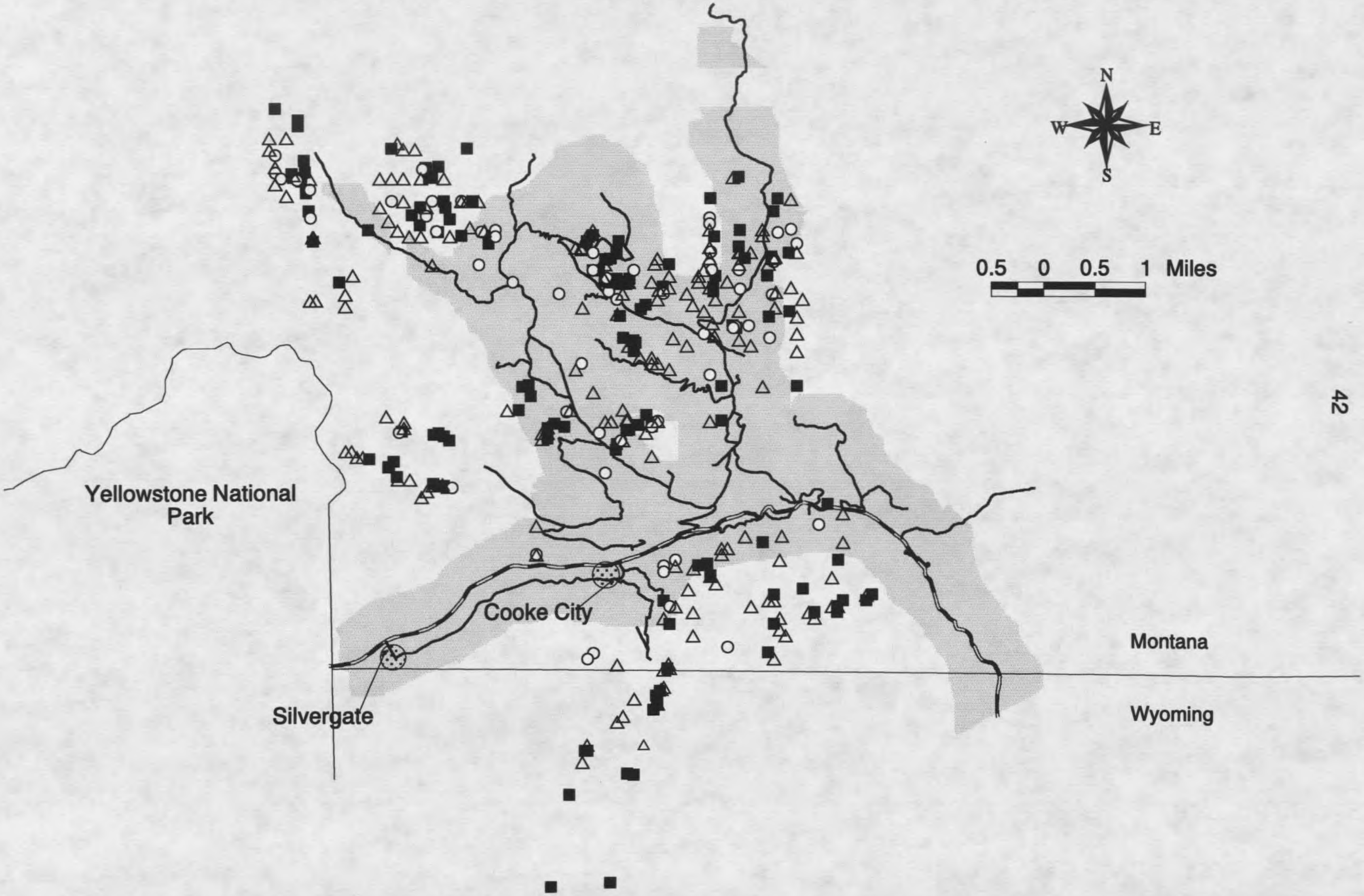

Figure 14. Distribution of all bear activity in relation to road density. Gray area represents road densities of $\geq$1,771 m/1,610 sq. m ($\geq$ 1.0 mi/sq. mi); white represents road densities of $\leq$1,610 m/1,610 sq. m ($\leq$ 1.0 mi/sq. mi). Solid boxes indicate grizzly bear activity, white circles indicate black bear activity, and open triangles indicate activity of unknown bear species.

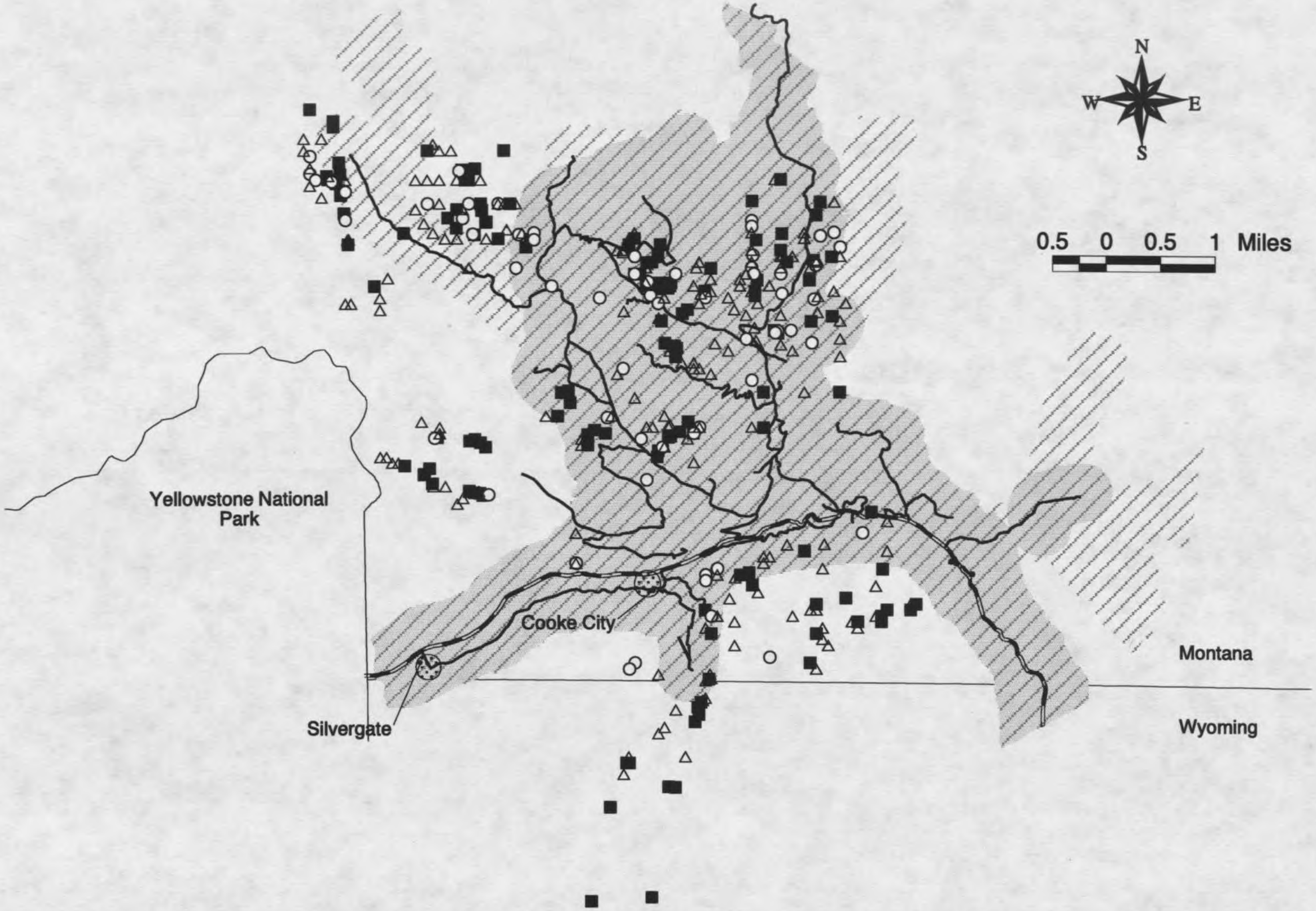

Figure 15. The distribution of all bear activity points in relation to "core" and "non-core" habitat. Gray area represents "non-core" habitat for season 1 (March 1 - July 15). Hatched area represents "non-core" habitat for season 2 (July 16 - November 30). White area represents "core" habitat for seasons 1 and 2. Solid boxes indicate grizzly bear activity, white circles indicate black bear activity, and open triangles indicate activity of unknown bear species.

DISCUSSION

Role of Study Area in Bear Population in The Northeast Yellowstone System

The mobility of grizzly and black bears and the variability in availability of high quality foods explain the high seasonal and annual variation in bear activity I recorded in my study area. Adult male grizzly bears travel on average 1.4 km/day (Blanchard and Knight 1991). Adult females trapped in Cooke City moved on average 1.7 and 1.5 km/day during summer and fall (Blanchard and Knight 1991). My study area was approximately 8 km by 11 km, and all of the subunits were adjacent to one another and easily accessed by bears. A bear at the head of Miller Creek could quickly access the Stillwater, Sheep Creek, or Fisher Creek subunits by traveling Daisy Pass, Bull of the Woods Pass, the saddle between Sunset Peak and Miller Mountain, or the unimproved road on Henderson Mountain.

The size of the study area (91 km^2) was less than a third of an adult female grizzly's mean annual range (281 km^2) and a tenth of an adult male's (874 km^2) in the YE (Blanchard and Knight 1991). Adult females monitored in the Cooke City area had a mean annual range of 425 km^2 (Blanchard and Knight 1991). The only radio collared grizzlies with home ranges smaller than my study area were two reported by Judd and Knight (1990), and these bears were trapped at the Cooke City dump. The dumps presumably represented an exceptionally dense food source and precluded the need for larger home ranges.

Reinhart and Mattson (1992) hypothesized that the Cooke City Basin study area was likely to support "major seasonal and annual" immigration and emigration of grizzly bears when high quality food sources were available. Whitebark pine nuts appeared to be the food driving use. Kendall (1983) found that red squirrel cone caches provided a concentrated, nutritious, high fatty food source, critical to bears during spring and fall. Fall use of pine cones/seeds in red squirrel middens, begins in August (Kendall 1983). Mattson and Reinhart (1994) found that grizzly bears obtain > 90% of whitebark pine seeds from red squirrel middens. Black bears also raid middens (Kendall 1983) and are capable of climbing trees and feeding on cones in the canopy or breaking limbs off and feeding on the forest floor (Mealey 1975).

There was a consistent increase in recorded bear activity in the Cooke City Basin following the successful whitebark pine cone crops of 1989, 1991, and 1996. During the fall of 1996, 53% or 40 of 75 activity sites were recorded in the study area. Whitebark pine seeds produced the previous fall also influenced spring bear activity. The exceptionally large pine nut crop of 1989 allowed bears to feed on seeds throughout spring and summer months during 1990. Bear activity was lowest in the study area during spring months that followed poor pine nut years. During the spring of 1991 and 1996, only 6% and 8% of the activity sites were recorded in the study area. Pine nut production influenced not only bear activity in whitebark pine habitat but for the entire study area. Reinhart and Mattson (1992) recorded a total of 111 bear activity sites (accounts for bear activity recorded on transects I repeated) in 1990 (year following high whitebark pine cone production) versus 73 activity sites in 1991 (year following low whitebark pine cone production).

Bear activity was not equally distributed throughout the study area. The density of bear activity found in the Miller Creek, Fisher Creek, Mud Lake, Stillwater, Republic Creek, Woody Creek and Sheep Creek subunits were similar. The Cooke Face subunit had consistently less bear activity than other subunits. The Cooke Face subunit was the most intensively managed [salvage timber sales of 1990-1994 and conifer reseeding projects during 1990-1996 (Roger Gown, GNF, pers. comm.)], had the lowest amount of forested canopy cover as a result of the fire perturbation of 1988, was in close proximity to Cooke City, and was bisected by two county roads.

Habitat quality played an important role in grizzly and black bear activity distribution. Mature whitebark pine habitat was the most valuable cover type. Bear activity was recorded in the mature whitebark pine cover type disproportionately more than expected, and the frequency of occurrence of whitebark pine seeds in bear scats indicated that the value of this cover type lay in food production. During poor years of cone production, bears are reported to select lower elevations (Blanchard and Knight 1991), but in this study, the mature whitebark pine cover type was important in good and bad cone years. Good cone crops preceded the failed crops of 1990 and 1997. During spring of 1990 and 1997, bears foraged whitebark pine seeds produced the preceding year and still available in red squirrel middens. Mattson and Jonkel (1990) found that bears sought out forest stands with a high whitebark pine basal area when foraging pine nuts from the previous fall crop. The increased bear activity recorded during years of successful cone production is a result of an ingress of bears to the Cooke City area. During years of inadequate whitebark pine cone production, bear activity either decreased in the study area (fall of 1997) or alternate food sources were sought out (grouse whortleberry during fall of 1990).

The mature subalpine fir cover type was used in proportion to its availability, but it was an abundant cover type and approximately 20% of all bear activity was recorded in this type. Chi-square analysis may have underestimated the importance of this type because it was abundant. A mature subalpine fir forest includes subalpine fir, Engelmann spruce, lodgepole pine, and whitebark pine. A mix of mature tree species accommodates greater squirrel densities than either pure lodgepole pine or whitebark pine cover types. In the Cooke City area, mixed forests of whitebark pine and lodgepole pine had the highest density of excavated squirrel middens (Mattson and Reinhart 1997). The lowest density of excavated middens occurred in forest stands dominated by lodgepole pine (Mattson and Reinhart 1997). Red squirrel densities were actually lowest in pure whitebark pine stands because squirrels are dependent upon alternate food sources during years of poor whitebark pine cone production (Reinhart and Mattson 1990). Bear use of forested cover types in this study area, therefore, represented a compromise between use of types with the most food production and use of types with the most food caches.

Open cover types (meadow mosaic and high elevation grassland and tundra) were used in proportion to their availability, except during the combined 1996-1997 period. The importance of open types may have been underrepresented due to my dependence on indirect evidence of bear activity. Bears ate a significant amount of forbs, grasses, and sedges found in open habitat and nonforested openings, but bears may not have occupied open habitat long enough to defecate, or they defecated before they entered open habitat. Feces were the most common evidence of bear activity recorded on transects.

Transect data shed light on the importance of small pockets of atypical vegetation included within larger habitat categories. The habitat classification scheme I used had a 2-acre resolution and missed many of these unique microsites within the forest matrix. A forested cover type (lodgepole pine, whitebark pine, or subalpine fir) adjacent to a forb-dominated meadow was the most frequent habitat microsite used by bears during the 1996-1997 period.

Food Habits

I based my food habits analysis on remains of food items in feces. This introduces several biases including differential digestibility of different food items, different levels of identification accuracy for different food items, and differential defecation rates for different seasons. Mattson et al. (1991) found that Yellowstone grizzlies ingested the greatest amount of food during July, August, and October and the least amount in April and [May?] June. This resulted in greater defecation rates during summer and fall months. In this study, the greatest number of bear feces was recorded during summer months, except during 1996 when bear fecal availability peaked during fall. Prichard and Robbins (1990) found that in captive grizzly and black bears, an animal diet was more digestible than a vegetal or mixed vegetal/animal diet. An inverse relationship exists between fiber content and dry matter digestibility (Prichard and Robbins 1990). Mealey (1980) estimated that the percentage of digestible protein from herbs was approximately half that of digestible starch from herbs, digestible protein and fat from animal matter, and digestible fat and protein from whitebark pine seeds.

Despite potential biases, grizzly and black bear food habits analysis I conducted illustrated the importance of whitebark pine seeds, forbs, and graminoids. The greatest occurrence of whitebark pine seeds was evident in spring scats. Even in years of poor pinecone production, whitebark pine cones were available to bears from preceding good years of cone production (Mattson et al. 1991, Mattson and Jonkel 1990). At higher elevations, such as my study area, snow depth dictates the success rate of obtaining whitebark pine cones from previous fall crops (Kendall 1983, Mattson and Jonkel 1990). Kendall (1983) found that red squirrels began caching whitebark pine cones/seeds during August; therefore, seeds may not be readily available in squirrel caches until early fall. While conducting fieldwork I observed a marked increase in squirrel activity in August. Over the 4 years of data I analyzed, the frequency of whitebark pine seeds in bear scat ranged from 30% in summer to 81% in spring across all years and was consistently one of the most important diet items.

The combined importance of grasses/sedges and forbs was evident from their consistently high frequency of occurrence from spring through fall. Although sample sizes are small, the frequency of occurrence of herbaceous material was greatest during lean or failed years of whitebark pine cone crops (spring 1991 and fall 1997). However, the combined frequency of occurrence of grasses/sedges and forbs was greater than whitebark pine during the fall of 1996, a year when cones were abundant (IGBST 1996). As in other studies (Mattson et al. 1991, Gunther 1994), the frequency of occurrence of grasses/sedges was greatest during summer months. This may present a biased view of their importance in spring. Immature plants have greater amounts of nutritive compounds and increased digestibility (Herrero 1985). The increased digestibility of herbaceous plants could have reduced their detectability in feces collected in spring.

Forbs were most commonly identified in summer and fall scats. Forbs occupied significantly less fecal volume than whitebark pine during all seasons. Mattson et al. (1991) reported that forbs were common in scats during all months, but that overall, fireweed was a minor scat component, while dandelion was a dominant scat component in June scats. However, I found that fireweed and dandelions were dominant components of bear scats collected throughout summer. Underground tubers, roots, and corms of forbs are sought by grizzly bears during all months (Servheen 1983, Herrero 1985, Mattson et al. 1991, Gunther 1994). Lomatium was the only excavated forb evident in grizzly bear scats I collected. Black bears are reported to be less capable of digging for underground structures (Herrero 1985), and I found no below ground structures in black bear scats. Mattson et al. (1991) reported the peak use of *Osmorhiza* sp., *Potamogeton* sp., and *Perideridia* sp. during September and October. In this study, *Potamogeton* sp. was not evident, while *Osmorhiza* sp. and *Perideridia* sp. were minor scat components. Mealey (1980) found that spring beauty (*Claytonia lanceolata*) was the most important bear food in the Gallatin and Washburn Ranges of YNP and was used primarily during summer months. *Claytonia lanceolata* was absent from scats in this study, although it was common in high elevation alpine meadows.

Overall, fleshy fruits were found in approximately 27% of all fall bear scats. *Vaccinium scoparium* was a dominant food item during fall of 1990. Grouse whortleberry supplemented the bear diet during the failed whitebark pine cone crop of 1990. Fleshy fruits were much more common in feces during the 1990-1991 period than during 1996-1997. The significant amount of grouse whortleberry identified in 1990-1991 scats is uncharacteristic due to the lack of berry crops and fruit producing shrubs in the GYE (Mattson et al. 1991). Fleshy fruits, especially grouse whortleberry, may potentially supplement bear diets during years of low whitebark pine cone production in the Cooke City Basin.

I found that meat was most common during fall months. Elk and red squirrel were the most common animal components found in bear scats. Other animal matter identified in scats included meat and hair from bear, moose, deer, and pocket gopher. Upon den emergence, grizzly and black bears orient themselves towards the Northern Winter Range of YNP. Winter-kill and elk calving grounds are found at these lower elevations (Mattson et al. 1997), south of Cooke City. Mattson (1997) found that ungulate consumption peaked in April and May (scavenging winterkill) and again in September and October (ungulate predation). Grizzly bears were observed preying on adult elk and calves from May through July in Pelican Valley, YNP (Gunther and Renkin 1990). Mattson (1997) found an inverse relationship between whitebark pine seed use and ungulate use. Mattson (1997) hypothesized that use of ungulates by bears was compensatory to whitebark pine seeds. The presence of bear matter in scats verifies the interspecific or intraspecific competition between grizzly and/or black bears. Mattson et al. (1992) documented five cases of grizzly bear cannibalism on other grizzlies and black bears between 1975 and 1990.

Peak use of ants in this study occurred during summer months in the 1990-1991 period. Overall, insects were the fourth most common diet item. Mattson et al. (1991) documented the peak use of ants during July and August, which coincides with the time when the average protein content in Yellowstone grizzly bear diet is lowest as a result of the low protein content in grasses. Mealey (1980) did not report the presence of insects in grizzly bear scats collected in YNP during 1973 and 1974.

The greatest frequency of occurrence of sporophytes (12% of 51 scats) occurred in summer black bear scats (Servheen 1983, Mattson et al. 1991). In contrast, approximately 6% of 108 summer grizzly bear scats contained evidence of sporophytes. Sporophytes were a minor scat component across all years.

To clearly understand grizzly and black bear food habits, research must span multiple years. Scat sample sizes in this study were questionable, but diet patterns were evident. The number of different diet items fluctuated among years and seasons, with the greatest diet diversity in summer months. In the Cooke City Basin, whitebark pine seeds were likely the food item with the most impact on bear habitat use and presence in the area.

Effects of Road Density, Core Area, and Cover

To manage human access within the grizzly bear recovery zone, Federal and State agencies utilize the grizzly bear/motorized access management guidelines, established by the IGBC Task Force (1998). Access management criteria used to assess human use levels include open road density, total motorized access route density, and "core" area (IGBC 1998). Road density alone fails to explain bear displacement from available habitat. These guidelines were established to quantify the negative effects of human activity on grizzly bear habitat use. However cover, which potentially fosters bear movements within close proximity to human activity is not an integral component to current management criteria.

Approximately 3, 943 and 1,548 vehicles traveled the Miller and Fisher Creek roads, respectively during 1991 (Reinhart and Mattson 1992). The estimated seasonal average daily traffic (SADT) volume for the Daisy and Lulu Pass area is 10 SADT for weekdays and 20-30 SADT for weekends. Traffic type is roughly 60% ATV, 30% 4x4, 5% sedan, and 5% mountain bike (Frank Ehernberger, GNF, pers. comm.). The 1994 SADT volume for the northeast entrance of YNP was 980 vehicles. The estimated 1999 SADT volume was projected at 1,159 vehicles (USDOT 1998). Despite these traffic volumes, the density of bear activity in the Fisher Creek and Miller Creek subunits was similar to bear activity recorded in the more remote Stillwater, Sheep Creek, and Republic Creek subunits.

Subunits with the highest density of roaded area and zones of influence (area in which grizzly bears would be effected by human activity) included the lower portion of the Woody Creek subunit, Miller Creek, Fisher Creek, and the Cooke Face. The Fisher and Miller Creek county road system, the Highway 212 corridor, and the town site of Cooke City are responsible for road densities/zones of influence that exceed 3,221m/1,610m^2 (2.0 mi/mi^2) in these subunits. I found no relationship between the distribution of all bear or black bear activity with road density. However, grizzly bear activity was recorded in areas with $\leq$ 1,610m/1,160m^2 ($\leq$ 1.0 mi/mi^2) of road more than expected. Grizzly bear activity was distributed proportionately among roaded areas that exceeded 1,771m/1,610m^2 (1.1 mi/mi^2).

It is well documented in the literature that grizzly and black bears are displaced from available habitat in juxtaposition to human activity (Schallenberger 1980, Schallenberger and Jonkel 1980, McLellan and Shackleton 1989, Gunther 1990, Fredrick 1991, Mattson et al. 1992, Mace et al. 1996). Human developments within YNP disrupted bear foraging activity out to 3 km from roads during spring (Mattson et al. 1987). Mattson and Reinhart (1997) found that zones of influence (buffered human activity or "non-core" area) decreased the probability of recording excavated squirrel middens near road and town sites by 1.3 and 2.6 times, respectively. In this study, with the exception of known grizzly bear activity in habitat with $\leq$ 1,610m/1610m^2 of road, bear activity was equally distributed among the two road density categories. It is clear that grizzly and black bears are utilizing heavily roaded and intensely managed habitat in close proximity to human activity. Bears are willing to take risks to acquire a high quality food source. Cover, in the form of forests aids bears in exploiting the important whitebark pine crop in the heavily roaded, high intensity, human use area of Cooke City, Montana.

"Core" and "non-core" habitat is correlated with the density of roaded area, but more importantly, it accounts for the intensity and type of human activity associated with roads and trails. Heavily roaded subunits (Fisher Creek, Miller Creek, Woody Creek, and Cooke Face) or those near other forms of human activity had less core habitat. I found no relationship between the distribution of all bear and grizzly bear activity with regard to "core" and "non-core" habitat. However, black bear activity was observed disproportionately less than expected in "core" habitat and more than expected in "non-core" habitat during spring and early summer. This result is a potential artifact of the small sample size (n = 61), but could be due to interspecific competition between grizzly and black bears (Kellyhouse 1975, Kendall 1984, Herrero 1985). Black bears are known to avoid simultaneous use of areas with grizzly bears. Mattson et al. (1997) suggested that black bear avoidance of competition with grizzly bears might force them into sub-optimal habitat. In this study, black bears occupied "non-core" habitat, which would be interpreted as sub-optimal.

The Miller Creek, Fisher Creek, Mud Lake, Cooke Face subunits, as well as the lower portion of the Woody Creek subunit were classified as having no "core" habitat for both seasons 1 and 2 (March 1 through November 30). The Stillwater subunit had significantly less "core" habitat during summer and fall than in spring and early summer, due to the access that the Lake Abundance road provides during summer and fall. The Cooke Face and Woody Creek subunits which had similar high values for roads and human influenced areas ("non-core" habitat), are both adjacent to highway 212. However, the Woody Creek subunit had significantly more bear activity than the Cooke Face subunit. The major difference that separates the Woody Creek area from the Cooke Face subunit is forested cover. The Woody Creek subunit had not been affected by fire and maintained dense forests of mature lodgepole pine, Engelmann spruce, and subalpine fir.

Forested cover in relation to a high quality food source potentially mitigates the negative effects that roads and human activity have on bear habitat use and movements. I found differences in the distribution of bear activity and forested cover. When all bear activity was pooled, it was found in forested cover and forested/open vegetative mosaics disproportionately more than in open habitat. Grizzly and black bear activity was also found disproportionately less than expected in open habitat.

CONCLUSION

Variables that influence bear habitat utilization include density of roads, cover, human activity, and food availability. In this study, the density of roaded area was not a critical factor with regard to bear habitat utilization. In general, bear activity was equally distributed among "core" (removed from roads and human activity) and "non-core" (close to roads and human activity) habitat. Black bear activity was less influenced by human activity levels than grizzly bear activity. The tendency of bears to avoid open areas more than roaded forested areas suggests that forested cover played a greater role in bear habitat utilization in the Cooke City Basin than road density.

The whitebark pine cone crop influenced bear movements in and out of the Cooke City area. The majority of whitebark pine seeds were consumed from overwintered cones available in squirrel middens. High concentrations of grizzly and black bear activity occurred in areas with high intensity human use during years of good cone crops. Bears are willing to occupy habitat in close proximity to human activity when a high quality food source is available. Cover is an important component in facilitating use of human occupied landscapes. Forests in the study area provided sufficient cover to screen bears from most human observations. In approximately 430 hours driving the study area and walking transects during my field research, I only observed one subadult grizzly bear.

Although whitebark pine seeds were a major determinate of bear use of the study area, forbs, grasses, and sedges were dominant food items during all months, with peak occurrence during summer. Bears occupied the Cooke City area during all months, not only in spring and fall when whitebark pine seeds were most commonly available. Bears were able to alter diets to compensate for whitebark pine shortages. Grouse whortleberry was a dominant diet item during the fall of 1990 when whitebark pine cones were in short supply. Ungulates were an insignificant scat component in all years. This probably reflects the low densities of ungulates in the area. Cover and the availability of high quality foods mitigate the risk bears will take to acquire whitebark pine seeds in the in the Cooke City Basin.

Management Implications

Most researchers working with bears in the Yellowstone area (Knight et al. 1988, Mattson and Reid 1991, Mattson 1993) believe that available bear habitat in the GYE will decline if the extraction of natural resources, recreation use, and development on public and private lands increase. These activities require access and past studies have proven the negative effects of roads on grizzly and black bears (Schallenberger and Jonkel 1980, Mattson et al. 1987, Kasworm and Manley 1990, Mattson et al. 1992, Mace et al. 1996). Additional roads increase the number and distribution of humans in previously remote areas. Firearms and food items, commonly associated with humans, facilitate confrontations and bear mortalities.

However, my study shows that bears are willing to occupy areas with comparatively high road density in some circumstances. Where this occurs, bears are trading the risk of human encounters for a high quality food source and/or avoiding interspecific or intraspecific competition. The presence of cover enables bears to occupy these habitats by providing opportunities to forage undetected. Other studies have shown the importance of cover (Blanchard 1983, McLellan and Shackleton 1989) and have recommended retaining cover as close as possible to road edges (Jonkel et al. 1981) and providing cover strips (100 m buffers) between roads and valuable bear use areas (Zager and Jonkel 1983).

The Gallatin National Forest Plan (USDA 1987) provides management direction in the Cooke City Basin, including cover retention standards to protect grizzly bear habitat. It stipulates:

1. No point within a timber harvest unit should exceed 600 feet from cover.

2. Where harvest units are located adjacent to openings, cover should be maintained on approximately 75 percent of the openings perimeter.
3. A minimum of 20 percent of each project area should be retained in hiding cover.
4. "Security areas" must be available to bears immediately adjacent to any project site.

Although the efficacy of these standards for protecting bear habitat have not been tested, they do demonstrate concern for maintaining cover for bears. However, models used to determine the impacts of management activities on bears do not incorporate these standards or otherwise assess effects of management activities on cover and are based only on road density determinations. Because of the importance placed on the models for conducting effects analysis, there is a risk of not giving cover adequate consideration in project planning and implementation. Until a model can be devised that incorporates cover assessments, managers must give extra attention to cover retention in grizzly bear habitat.

Because road density alone does not determine bear habitat use, I recommend additional investigation of bear habitat use patterns in relation to cover. A better understanding of nocturnal bear habitat use is necessary before areas with high road densities are deemed underutilized by grizzly and black bears. Cover management standards, such as those given in the Gallatin Forest Plan, should be tested. Technological advances in radio telemetry (GPS collars) will aid in obtaining these data.

The presence of humans in areas of intense bear activity increases the probability of human-bear conflicts. To avoid bear mortalities, seasonal and/or permanent road closures in areas with important food sources for bears should be considered whenever possible. This includes whitebark pine forests, especially during years of good cone production.

Unroaded landscapes provide the best grizzly bear habitat. The Cooke City Basin represents sub-optimal habitat, defined by road density, human activity levels, and their associated risks. However, as the grizzly bear population expands in the YE and habitat is reduced and/or occupied by adult males, subordinate bear population classes may be forced into this and similar areas (Mattson and Reinhart 1990, Mattson and Reid 1991, Mattson 1993). We were not able to determine the age and sex of bears using the Cooke City Basin, but the amount of bear activity recorded by Reinhart and Mattson (1992) and myself indicates its importance to bears. Therefore, the Cooke City Basin and other heavily roaded habitat with good bear foraging opportunities and adequate cover should not be regarded as sacrifice areas when bear habitat needs in the GYE are determined. Grizzly bear management practices such as cover retention, good sanitation practices, travel restrictions, and public education should be given as much or more consideration in these areas as in stereotypic grizzly bear habitat.

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APPENDICES

APPENDIX A

FIELD FORM USED TO RECORD GRIZZLY BEAR AND BLACK BEAR ACTIVITY

Figure 16. The habitat field form used to record bear activity data during 1996 and 1997.

Habitat Field Form

Key # _ _ _ UTM _ _ _ _ _ _ _ _ _ Date _ _/_ _/_
_

OBS _ _/_ _/_ _ REF PT. _ _ _ _ _ _ _ _ _ Sign age _ _ _ _

Day bed: Y N Scat: Y N (#_ _)

Aspect _ _ _ Slope _ _ _ % Elev. _ _ _ _ _
ft.

Landform: R US MS LS BNCH BOT

Distance to: For/NFor _ _ _ _ m Habitat type _ _ _ _ _ Cover type _ _ _ _ _

Physiogomy:

Burned: Y N

Daybed: Length _ _ _ dc. Width _ _ _ dc. Depth _ _ _ dc.

Dist. Tree _ _ _ dc. Tree Id. _ _ _ Dist. Dead/Down fall _ _ _ dc

Carcass (Measurements and description):

Spp:________________________

Sex:________________________

Age class:____________________

APPENDIX B

SUMMARY OF BEAR ACTIVITY RECORDED ALONG TRANSECT ROUTES DURING 1996 AND 1997

Table 9. The number of bear activity sites and density of bear activity recorded along transect routes within the 8 subunits during 1996.

Subunit	Transect	Transect Length	Date Sampled	Recorded bear Activities[1]	Activity Density (Sites/Km)[2]
Fisher Creek	FC1	3313 m	7-17-96	0	0
			8-16-96	3	0.91
			9-23-96	0	0
			10-08-96	0	0
	FC2	3123 m	7-17-96	0	0
			8-16-96	0	0
			9-23-96	2	0.64
			10-08-96	2	0.64
	FC3	715 m	7-23-96	0	0
			8-16-96	1	1.40
			9-16-96	0	0
			10-06-96	0	0
	FC4	856 m	7-23-96	0	0
			8-16-96	0	0
			9-16-96	2	2.34
			10-06-96	0	0
	FC5	976 m	7-23-96	1	1.03
			8-16-96	1	1.03
			9-16-96	0	0
			10-07-96	1	1.03
	FC6	931 m	7-23-96	0	0
			8-16-96	0	0
			9-16-96	0	0
			10-07-96	0	0
				N = 13	$\bar{x}$ = 0.33
Miller Creek	MC1	1107 m	7-24-96	0	0
			8-18-96	0	0
			10-07-96	0	0
	MC2	1770 m	7-24-96	0	0
			8-18-96	0	0
			10-07-96	2	1.13
	MC3	1553	7-25-96	0	0
			8-19-96	0	0
			10-07-96	1	0.64
	MC4	1960 m	7-25-96	0	0
			8-19-96	0	0
			10-07-96	0	0

Table 9 continued.

Subunit	Transect	Transect Length	Date Sampled	Recorded bear Activity[1]	Activity Density (Sites/Km)[2]
Miller Creek Cond.	MC5	1340 m	7-25-96	0	0
			8-19-96	2	1.53
			10-07-96	3	2.30
				N = 8	$\bar{x}$ = 0.35
Mud Lake	ML 1	3059 m	7-24-96	1	0.33
			8-17-96	2	0.65
			10-03-96	1	0.33
	ML 2	3263 m	7-24-96	0	0
			8-17-96	1	0.31
			10-03-96	5	1.53
	ML 3	3264 m	7-24-96	0	0
			8-17-96	0	0
			10-04-96	3	0.92
	ML 4	3508 m	7-24-96	0	0
			8-17-96	0	0
			10-04-96	1	0.29
				N = 14	$\bar{x}$ = 0.36
Still-Water	SW 2	2014 m	8-21-96	0	0
			9-24-96	0	0
			10-09-96	0	0
	SW 4	2227 m	8-02-96	1	0.45
			8-21-96	1	0.45
			9-24-96	0	0
			10-09-96	2	0.90
	SW 6	1538 m	8-02-96	0	0
			8-21-96	0	0
			9-24-96	1	0.65
			10-09-96	2	1.30
	SW 9	3307 m	8-02-96	4	1.21
			8-21-96	0	0
			9-24-96	2	0.61
			10-09-96	3	0.91
				N = 16	$\bar{x}$ = 0.47
Republic Creek	RC 1	4347 m	7-29-96	2	0.46
			8-20-96	0	0
			10-08-96	1	0.23
	RC 2	5338 m	8-03-96	0	0
			8-20-96	3	0.56
			10-08-96	6	1.12
				N = 12	$\bar{x}$ = 0.43

Table 9 continued.

Subunit	Transect	Transect Length	Date Sampled	Recorded bear Activity[1]	Activity Density (Sites/Km)[2]
Sheep Creek	SC 1	2501 m	7-26-96	0	0
			8-19-96	0	0
			10-04-96	2	0.80
			10-13-96	1	0.40
	SC 2	2963 m	7-26-96	0	0
			8-19-96	1	0.34
			10-04-96	3	1.01
			10-13-96	1	0.34
				N = 8	$\bar{x}$ = 0.37
Woody Creek	WC 1	3502 m	8-01-96	1	0.29
			8-22-96	1	0.29
			10-05-96	0	0
			11-12-96	0	0
	WC 2	3725 m	7-30-96	1	0.27
			8-22-96	1	0.27
			10-05-96	0	0
			11-12-96	0	0
				N = 4	$\bar{x}$ = 0.14

1. Bear activity includes feces, tracks, day beds, observations, excavated squirrel middens, flipped rocks, and torn logs.
2. Activity density: The number of bear activity sites per kilometer of transect.

Table 10. The number of bear activity sites and density of bear activity recorded along transect routes within the 8 subunits during 1997.

Subunit	Transect	Transect Length	Date Sampled	Recorded bear Activity[1]	Activity Density (Sites/Km)[2]
Fisher Creek	FC1	3313 m	7-18-97	0	0
			8-17-97	0	0
			9-29-97	1	0.30
	FC2	3123 m	7-18-97	0	0
			8-17-97	1	0.32
			9-29-97	0	0
	FC3	715 m	7-18-97	0	0
			8-15-97	0	0
			9-29-97	0	0
			10-17-97	0	0
	FC4	856 m	7-18-97	1	1.17
			8-15-97	2	2.34
			9-29-97	0	0
			10-17-97	0	0
	FC5	976 m	7-18-97	2	2.05
			8-15-97	1	1.03
			9-29-97	0	0
			10-17-97	0	0
	FC6	931 m	7-18-97	2	2.15
			8-15-97	1	1.07
			9-29-97	0	0
			10-17-97	0	0
				N = 13	$\bar{x} = 0.39$
Miller Creek	MC1	1107 m	7-23-97	0	0
			8-18-97	0	0
			9-28-97	0	0
	MC2	1770 m	7-23-97	0	0
			8-18-97	1	0.57
			9-28-97	0	0
	MC3	1553	7-23-97	0	0
			8-18-97	3	1.93
			9-28-97	1	0.64
	MC4	1960 m	7-23-97	0	0
			8-18-97	0	0
			9-28-97	0	0
	MC5	1340 m	7-23-97	2	1.49
			8-18-97	2	1.49
			9-28-97	0	0
				N = 9	$\bar{x} = 0.39$

Table 10 continued.

Subunit	Transect	Transect Length	Date Sampled	Recorded bear Activity[1]	Activity Density (Sites/Km)[2]
Mud Lake	ML 1	3059 m	7-24-97	3	0.98
			8-31-97	1	0.24
			10-01-97	0	0
			10-17-97	0	0
	ML 2	3263 m	7-24-97	1	0.31
			8-31-97	0	0
			10-01-97	0	0
			10-17-97	0	0
	ML 3	3264 m	7-24-97	5	1.53
			8-31-97	3	0.92
			10-01-97	3	0.92
	ML 4	3508 m	7-25-97	0	0
			8-31-97	0	0
			10-01-97	1	0.29
				N = 17	$\bar{x} = 0.37$
Still-Water	SW 2	2014 m	7-22-97	0	0
			8-29-97	1	0.50
			9-26-97	0	0
	SW 4	2227 m	7-22-97	3	1.35
			8-29-97	3	1.35
			9-26-97	4	1.80
	SW 6	1538 m	7-22-97	1	0.65
			8-29-97	0	0
			9-26-97	1	0.65
	SW 9	3307 m	7-22-97	2	0.61
			8-29-97	1	0.30
			9-26-97	0	0
				N = 16	$\bar{x} = 0.59$
Republic Creek	RC 1	4347 m	7-25-97	1	0.23
			9-01-97	2	0.46
			9-30-97	4	0.92
	RC 2	5338 m	7-25-97	2	0.38
			9-01-97	2	0.38
			9-30-97	4	0.75
				N = 15	$\bar{x} = 0.52$
Sheep Creek	SC 1	2501 m	7-16-97	0	0
			8-28-97	2	0.80
			9-25-97	2	0.80

Table 10 continued.

Subunit	**Transect**	**Transect Length**	**Date Sampled**	**Recorded bear Activity**[1]	**Activity Density (Sites/Km)**[2]
Sheep Creek Cond.	SC 2	2963 m	7-16-97	0	0
			8-28-97	3	1.01
			9-25-97	3	1.01
				N = 10	$\bar{x}$ = 0.61
Woody Creek	WC 1	3502 m	7-05-97	0	0
			8-17-97	0	0
			9-16-97	1	0.29
			10-09-97	2	0.57
	WC 2	3725 m	7-05-97	0	0
			8-17-97	2	0.54
			9-16-97	1	0.27
			10-09-97	0	0
				N = 6	$\bar{x}$ = 0.21
Cooke Face	CC 1	5501 m	7-05-97	0	0
			9-02-97	0	0
			9-15-97	0	0
			10-09-97	0	0
	CC 2	5904 m	7-23-97	0	0
			9-02-97	0	0
			9-15-97	2	0.34
			10-09-97	0	0
				N = 2	$\bar{x}$ = 0.04

1. Bear activity includes feces, tracks, day beds, observations, excavated squirrel middens, flipped rocks, and torn logs.
2. Activity Density: The number of bear activity sites per kilometer of transect.

APPENDIX C

CHI-SQUARE (X^2) SUMMARIES FOR GRIZZLY BEAR AND BLACK BEAR COVER TYPE USE VERSUS AVAILABILITY

Table 11. Chi-square (X^2) analysis for bear cover type use versus availability across all years within a 250 m buffered transect area. A total of 382 bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974): $X^2 = 104.80$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Mature whitebark pine	80	39.45	0.209	0.151-0.267	0.103	>
Mature whitebark pine mosaic	82	49.39	0.215	0.156-0.274	0.129	>
Mature subalpine fir	74	69.72	0.194	0.137-0.251	0.183	=
Mature subalpine fir mosaic	13	24.41	0.034	0.008-0.060	0.063	<
Disturbed subalpine fir mosaic	19	18.11	0.050	0.019-0.081	0.047	=
Mature lodgepole pine	30	41.45	0.079	0.040-0.118	0.109	=
Meadow mosaic	28	26.82	0.073	0.036-0.110	0.070	=
High elevation grassland/tundra	21	25.67	0.055	0.022-0.088	0.067	=
Rock	13	23.68	0.034	0.008-0.060	0.062	<
Other	22	63.45	0.058	0.024-0.092	0.166	<

Table 12. Chi-square (X^2) analysis for grizzly bear cover type use versus availability across all years within a 250 m buffered transect area. A total of 134 grizzly bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 72.85$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Mature whitebark pine	34	13.80	0.254	0.151-0.357	0.103	>
Mature whitebark pine mosaic	29	17.33	0.216	0.119-0.313	0.129	=
Mature subalpine fir	23	24.46	0.172	0.083-0.261	0.183	=
Mature subalpine fir mosaic[a]						
Disturbed subalpine fir mosaic	9	6.35	0.067	0.008-0.126	0.474	=
Mature lodgepole pine	8	14.54	0.060	0.004-0.116	0.109	=
Meadow mosaic	17	9.41	0.127	0.048-0.206	0.702	=
High elevation grassland/tundra[a]						
Rock	5	8.31	0.037	0.008-0.082	0.062	=
Other	9	39.81	0.067	0.008-0.126	0.297	<

[a]Consolidated into the "other" cover type category.

Table 13. Chi-square (X^2) analysis for bear cover type use versus availability within a 250 m buffered transect area in 1990 and 1991 combined. A total of 235 bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 49.03$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Mature whitebark pine	41	24.21	0.174	0.105-0.243	0.103	>
Mature whitebark pine mosaic	54	30.32	0.230	0.153-0.307	0.129	>
Mature subalpine fir	43	43.01	0.183	0.112-0.254	0.183	=
Mature subalpine fir mosaic	9	15.04	0.038	0.053-0.073	0.064	=
Disturbed subalpine fir mosaic	9	11.28	0.038	0.053-0.073	0.048	>
Mature lodgepole pine	22	25.62	0.094	0.041-0.147	0.109	=
Meadow mosaic	11	16.45	0.047	0.008-0.086	0.070	=
High elevation grassland/tundra	18	15.75	0.077	0.028-0.126	0.067	=
Rock	11	14.57	0.047	0.008-0.086	0.062	=
Other	17	39.01	0.072	0.025-0.119	0.166	<

Table 14. Chi-square (X^2) analysis for bear cover type use versus availability within a 250 m buffered transect area in 1996 and 1997 combined. A total of 147 bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 81.03$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Mature whitebark pine	39	15.14	0.265	0.163-0.367	0.103	>
Mature whitebark pine mosaic	28	18.93	0.190	0.099-0.281	0.129	=
Mature subalpine fir	31	26.90	.0211	0.116-0.306	0.183	=
Mature subalpine fir mosaic	4	9.41	0.027	0.011-0.065	0.064	=
Disturbed subalpine fir mosaic	10	7.06	0.068	0.010-0.126	0.048	=
Mature lodgepole pine	8	16.02	0.054	0.002-0.106	0.109	<
Meadow mosaic	17	10.29	0.116	0.042-0.190	0.070	=
High elevation grassland/tundra	3	9.85	0.020	0.012-0.052	0.067	<
Rock	2	9.11	0.014	0.013-0.041	0.062	<
Other	5	24.40	0.034	0.008-0.076	0.166	<

Table 15. Chi-square (X^2) analysis for bear cover type use versus availability within a 250 m buffered transect area in 1990 and 1997 combined ("poor" whitebark pine cone production years). A total of 203 bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 71.35$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Mature whitebark pine	44	20.91	0.217	0.136-0.246	0.103	>
Mature whitebark pine mosaic	49	26.25	0.241	0.157-0.325	0.129	>
Mature subalpine fir	43	37.05	0.212	0.131-0.293	0.183	=
Mature subalpine fir mosaic	5	12.97	0.025	0.006-0.056	0.064	<
Disturbed subalpine fir mosaic	6	9.62	0.030	0.004-0.064	0.048	=
Mature lodgepole pine	12	22.03	0.059	0.013-0.105	0.109	<
Meadow mosaic	10	14.25	0.049	0.006-0.092	0.070	=
High elevation grassland/tundra	12	13.64	0.059	0.013-0.105	0.067	=
Rock	7	12.59	0.034	0.002-0.070	0.062	=
Other	15	33.72	0.074	0.022-0.126	0.166	<

Table 16. Chi-square (X^2) analysis for bear cover type use versus availability within a 250 m buffered transect area in 1991 and 1996 combined ("good" whitebark pine cone production years). A total of 179 bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 47.41$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Mature whitebark pine	36	18.43	0.201	0.117-0.285	0.103	>
Mature whitebark pine mosaic	33	23.14	0.184	0.103-0.265	0.129	=
Mature subalpine fir	31	32.67	0.173	0.094-0.252	0.183	=
Mature subalpine fir mosaic	8	11.44	0.045	0.001-0.089	0.064	=
Disturbed subalpine fir mosaic	13	8.48	0.073	0.018-0.128	0.048	=
Mature lodgepole pine	18	19.42	0.101	0.038-0.164	0.109	=
Meadow mosaic	18	12.57	0.101	0.038-0.164	0.070	=
High elevation grassland/tundra	9	12.03	0.050	0.004-0.096	0.067	=
Rock	6	11.10	0.034	0.004-0.072	0.062	=
Other	7	29.73	0.039	0.002-0.080	0.166	<

Table 17. Chi-square (X^2) cover type use versus availability analysis for all bear locations across all years within a 250 m buffered transect area. A total of 382 bear locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 33.88$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Open	62	113.52	0.162	0.117-0.207	0.297	<
Forested/Open mosaic	121	96.39	0.317	0.260-0.374	0.252	>
Forested	199	172.08	0.521	0.460-0.582	0.450	>

Table 18. Chi-square (X^2) cover type use versus availability analysis for known grizzly bear locations across all years within a 250 m buffered transect area. A total of 134 locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 17.89$; $P < 0.001$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Open	18	39.82	0.134	0.064-0.205	0.297	<
Forested/Open mosaic	46	33.81	0.343	0.245-0.442	0.252	=
Forested	70	60.36	0.522	0.419-0.626	0.450	=

Table 19. Chi-square (X^2) cover type use versus availability analysis for known black bear locations across all years within a 250 m buffered transect area. A total of 61 locations were used in analysis. Confidence intervals determined if use was >, <, or = to expected (Neu et al. 1974). $X^2 = 6.57$; $P = 0.0375$

Cover Type	Number Observed	Number Expected	Percent Observed	Confidence Interval	Percent Expected	>, <, or = to Expected
Open	10	18.13	0.164	0.050-0.277	0.297	<
Forested/Open mosaic	22	15.39	0.361	0.213-0.508	0.252	=
Forested	29	27.48	0.475	0.322-0.629	0.450	=

APPENDIX D

FOOD HABITS SUMMARY FOR GRIZZLY BEAR AND BLACK BEAR SCATS COLLECTED DURING 1990, 1991, 1996, AND 1997

Table 20. Scat contents of all bear scats collected across all years.

	Spring N = 51		Summer N = 268		Fall N = 109	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	80.8	70.4	30.2	13.6	45.0	23.7
Fleshy Fruits						
Amelanchier			0.4	T		
Ribes			1.1	0.1	1.8	0.1
Sheperdia			3.0	0.1		
Symphoricarpos			2.2	T	0.9	T
Vaccinium	3.9	0.1	10.8	0.8	23.9	9.5
Sporophytes						
Equisetum	3.9	1.0	6.0	0.1	2.8	0.1
Lycopodium			1.1	T	1.8	T
Grass/Sedge						
Agropyron					0.9	T
Bromus			0.8	T		
Carex	5.9	0.3	14.6	1.3	12.8	1.3
Deschampsia	2.0	T	0.4	T		
Juncus					0.9	T
Phleum	2.0	T	1.5	T	2.8	0.1
Poa	19.6	1.2	32.8	2.6	17.4	1.0
Other	13.7	0.4	6.3	0.3	4.6	0.1
Forbs						
Agoseris	2.0	0.1	3.4	0.2	1.8	0.1
Angelica					0.9	T
Astragalus			0.8	T	1.8	0.1
Cirsium	3.9	0.1	3.7	0.3	4.6	0.4
Epilobium			17.2	3.1	10.1	0.7
Fragaria					0.9	T
Heraculum			1.1	0.1	0.9	T
Lathyrus			1.5	T		
Ligusticum					0.9	T
Lomatium			0.8	T		
Osmorhiza			4.5	0.6	0.9	0.2
Perideridae					1.8	0.2
Stellaria			0.4	T		
Taraxacum	5.9	1.1	24.6	3.3	13.8	1.4
Tragopogon			0.4	T		
Trifolium	2.0	0.3	9.0	0.4	2.8	0.1
Other			5.2	0.1	4.6	0.4
Insects						
Ants	13.7	0.4	18.7	0.4	7.3	T
Maggots			0.8	T	0.9	T
Tetraonidae	2.0	T				
Other			0.4	T		
Miscellaneous						
Debris	29.4	5.3	24.6	1.9	13.8	0.4
Garbage	2.0	T				
Pine needles					0.9	T
Unidentified root	3.9	T				

Table 20 continued.

Diet Item	Spring N=51		Summer N = 268		Fall N = 109	
	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.
Animal						
Moose			0.4	T	0.8	T
Elk	2.0	T	3.7	T	8.3	0.3
Mule deer			0.4	T		
N. pocket gopher			0.4	T		
Red squirrel			0.8	T	3.7	T
Ursidae			1.5	T	2.8	T
Cervidae	3.9	0.2	1.9	T		
Unidentified						
Bird			0.8	T		

Trace (less than 0.1)

Table 21. Scat contents of all grizzly bear scats collected across all years.

	Spring N = 26		Summer N = 108		*Fall N = 67	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	88.5	86.2	18.5	2.9	49.3	27.6
Fleshy Fruits						
Ribes					1.5	T
Sheperdia			1.9	T		
Symphoricarpos			1.9	T		
Vaccinium			9.3	2.4	7.5	0.1
Sporophytes						
Equisetum	7.7	5.0	5.6	0.2	3.0	T
Lycopodium			0.9	T	3.0	T
Grass/Sedge						
Agropyron					1.5	T
Bromus			1.9	T		
Carex	7.7	1.2	16.7	1.0	17.9	1.9
Deschampsia	3.9	T	0.9	T		
Juncus					1.5	T
Phleum			0.9	T	1.5	T
Poa	3.9	T	25.0	2.0	10.5	0.5
Other	11.5	0.1	7.4	0.8	6.0	0.1
Forbs						
Agoseris			1.9	0.1	1.5	0.1
Astragalus					3.0	0.1
Cirsium			4.6	0.3	6.0	0.5
Epilobium			25.0	5.7	11.9	1.2
Heracleum			0.9	0.1	1.5	T
Lathyrus			0.9	T		
Lomatium			0.9	T		
Ozmorhiza			2.8	0.1	4.5	0.3
Stellaria			0.9	T		
Taraxacum	5.1	1.0	25.9	3.8	19.4	2.8
Tragopogon			0.9	T		
Trifolium			9.3	0.8	4.5	0.2
Other			8.3	0.5	6.0	0.7
Insects						
Ants	7.7	T	24.1	1.3	10.5	T
Maggots					1.5	T
Miscellaneous						
Debris	11.5	2.9	26.9	2.8	9.0	0.3
Animal						
Moose					1.5	T
Elk			1.9	T	7.5	0.3
Mule deer			0.9	0.1		
Red squirrel					4.5	T
Ursidae					4.5	T
Cervidae	3.9	0.8	2.8	0.1		
Unidentified Bird			1.9	T		

Trace (less than 0.1)
*No fall data for 1990

Table 22. Scat contents of all black bear scats collected across all years.

	Spring N = 9		Summer N = 51		*Fall N = 11	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	77.8	42.7	27.5	12.2	54.6	24.2
Fleshy Fruits						
Sheperdia			5.9	T		
Vaccinium	11.1	0.2	5.9	0.1	18.2	3.5
Sporophytes						
Equisetum			11.8	0.5	27.3	3.0
Grass/Sedge						
Carex	11.1	0.7	25.5	7.4	27.3	3.1
Poa	33.3	5.0	37.3	4.3	54.6	5.9
Other			7.8	0.5		
Forbs						
Agoseris	11.1	2.6	2.0	T	9.1	0.1
Astragalus			3.9	0.3		
Cirsium	11.1	2.2	3.9	0.2	9.1	0.5
Epilobium			7.8	0.9	27.3	1.3
Fragaria					9.1	0.1
Heracleum			3.9	0.8		
Lathyrus			2.0	0.1		
Ozmorhiza			11.8	3.7		
Taraxacum			19.6	2.4	9.1	0.1
Trifolium	11.1	9.4	11.8	0.4		
Other			2.0	T	9.1	1.0
Insects						
Ants	22.2	2.7	17.7	0.4		
Miscellaneous						
Debris	22.2	5.6	17.7	1.0	9.1	4.5
Pine needles					9.1	4.5
Animal						
Elk			7.8	0.2	9.1	T
Red squirrel					9.1	T
Ursidae					9.1	T
Cervidae	11.1	0.3	3.9	T		

Trace (less than 0.1)
*No fall data for 1997.

Table 23. Scat contents for all bear scats collected during 1990.

	Spring N=17		Summer N=97		Fall N = 19	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	94.1	80.9	67.0	54.4	5.3	1.3
Fleshy Fruits						
Ribes			2.1	0.2	5.3	5.3
Symphoricarpos			6.1	0.2	5.3	0.1
Vaccinium	5.9	0.3	19.6	9.2	79.0	64.2
Sporophytes						
Equisetum			5.2	1.5		
Lycopodium			0.4	1.0		
Grass/Sedge						
Carex	5.9	1.2	4.1	1.7		
Phleum	5.9	1.5	2.1	0.3	5.3	T
Poa	47.1	5.4	41.2	5.7	10.5	5.0
Other	23.5	3.9	9.3	2.9	10.5	2.4
Forbs						
Agoseris			1.0	0.1		
Angelica					5.3	0.3
Cirsium	5.9	1.5	1.0	0.5		
Lathyrus			3.1	2.9		
Ligusticum					5.3	4.7
Perideridae					10.5	10.5
Taraxacum			14.4	5.2		
Trifolium			8.3	2.0		
Other			7.2	1.7		
Insects						
Ants	23.5	2.3	20.6	3.1		
Tetraonidae			1.0	T		
Other			1.0	0.1		
Miscellaneous						
Debris	58.8	8.4	33.0	6.8	36.8	3.7
Garbage	5.9	0.6				
Pine needles					5.3	2.6
Animal						
Moose			1.0	T		
Elk	5.9	T	7.2	0.8		
Red squirrel			2.1	0.2		
Ursidae			4.1	0.4		
Cervidae			2.1	T		
Unidentified bird			2.1	T		

Trace (less than 0.1)

Table 24. Scat contents for all bear scats collected during 1991.

	Spring N=5		Summer N=84		Fall N = 38	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine			3.6	1.7	84.2	70.8
Fleshy Fruits						
Amelanchier			1.2	T		
Ribes			1.2	T		
Sheperdia			7.1	2.0		
Vaccinium			9.5	5.0	26.3	6.5
Sporophytes						
Equisetum	40.0	26.0	6.0	1.1		
Lycopodium			1.2	T	2.6	0.4
Grass/Sedge						
Bromus			2.4	0.4		
Carex	40.0	6.0	21.4	11.6	5.3	1.5
Poa	40.0	8.0	39.3	10.5	39.5	6.0
Other			1.2	1.0		
Forbs						
Agoseris			9.5	6.4	2.6	0.3
Cirsium			1.2	1.2		
Epilobium			38.1	22.0	10.5	2.5
Fragaria					2.6	0.3
Taraxacum	40.0	26.6	36.9	14.9	7.9	0.5
Tragopogon			1.2	0.3		
Trifolium	20.0	17.0	14.3	4.6		
Other			7.1	4.5	5.3	3.2
Insects						
Ants	20.0	0.2	23.8	1.8	7.9	0.4
Maggots			1.2	T		
Tetraonidae	20.0	1.2			2.6	0.1
Miscellaneous						
Debris	20.0	14.0	27.4	10.1	15.8	3.0
Unidentified root	40.0	1.0				
Animal						
Moose					5.3	0.1
Elk			3.6	0.3	23.6	3.3
N. pocket gopher			1.2	T		
Red squirrel					5.3	T

Trace (less than 0.1

Table 25. Scat contents for all bear scats collected during 1996.

	Spring N = 4		Summer N =32		Fall N = 42	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	25.0	24.3			31.0	27.9
Fleshy Fruits						
Ribes					2.4	0.1
Sheperdia			6.3	0.2		
Vaccinium	25.0	5.0			2.4	2.4
Sporophytes						
Equisetum			12.5	5.0	7.1	3.6
Lycopodium					2.4	0.1
Grass/Sedge						
Carex			28.1	9.6	28.6	11.4
Phleum			3.1	1.3	2.4	0.3
Poa			15.6	5.5	4.8	1.8
Juncus					2.4	0.5
Other			3.1	3.1	7.1	4.5
Forbs						
Agropyron					2.4	0.7
Astragalus			6.3	2.7	4.8	2.6
Cirsium			12.5	12.2	9.5	7.5
Epilobium			6.3	4.9	11.9	5.5
Heracleum			9.4	9.3	2.4	2.4
Osmorhiza			9.4	5.6	4.8	4.7
Taraxacum	25.0	1.3	31.3	18.2	23.8	14.4
Trifolium			12.5	6.6	7.1	4.2
Stellaria			3.1	1.3		
Other			3.1	2.2	2.4	1.0
Insects						
Ants	50.0	6.3	18.8	2.0	11.9	0.5
Miscellaneous						
Debris	75.0	57.5	18.8	5.4	4.8	1.7
Animal						
Red squirrel					4.8	0.1
Mule deer			3.1	2.8		
Ursidae					7.1	0.1
Cervidae	50.0	5.8	9.4	3.1		

Trace (less than 0.1)

Table 26. Scat contents for all bear scats collected during 1997.

	Spring N=25		Summer N=55		Fall N=10	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	100.0	90.8	23.6	7.4	30.0	17.0
Fleshy Fruits						
Vaccinium			3.6	0.4		
Sporophytes						
Equisetum			3.6	1.9		
Lycopodium			1.8	1.8		
Grass/Sedge						
Carex			14.6	4.3		
Deschampsia	4.0	0.2	1.8	1.4		
Phleum			1.8	1.6	10.0	8.5
Poa			18.2	8.6		
Other	12.0	1.4	10.9	9.5	10.0	4.0
Forbs						
Agoseris	4.0	3.8			10.0	5.0
Angelica						
Cirsium	4.0	3.2	7.3	4.7	10.0	10.0
Epilobium			21.8	18.3	20.0	20.0
Lathyrus			1.8	1.8		
Lomatium			3.6	2.4		
Osmorhiza			16.4	15.9	10.0	10.0
Perideridae						
Taraxacum			20.0	14.4	20.0	5.5
Other			1.8	1.8	20.0	20.0
Insects						
Ants	4.0	0.2	7.3	0.6		
Miscellaneous						
Debris	4.0	0.4	9.1	3.4		
Animal						
Unidentified bird			1.8	T		

Trace (less than 0.1)

Table 27. Scat contents of all bear scats collected during the combined 1990-1991 period.

	Spring N=22		Summer N=181		Fall N = 57	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	72.7	58.9	37.6	19.6	57.9	38.3
Fleshy Fruits						
Amelanchier			0.6	T		
Ribes			1.7	T	1.8	0.1
Sheperdia			3.3	0.1		
Symphoricarpos			3.3	0.1	1.8	T
Vaccinium	4.6	T	14.9	1.2	43.9	18.0
Sporophytes						
Equisetum	9.1	2.4	5.5	0.1		
Lycopodium			1.1	T	1.8	T
Grass/Sedge						
Bromus			1.1	T		
Carex	13.6	0.6	12.2	1.2	3.5	0.1
Phleum	4.6	0.1	1.1	T	1.8	T
Poa	45.5	2.7	40.3	3.2	29.8	1.8
Other	18.2	0.7	5.5	0.2	3.5	0.1
Forbs						
Agoseris			5.0	0.3	1.8	T
Angelica					1.8	T
Cirsium	4.6	0.1	1.1	T		
Epilobium			17.7	3.9	7.0	0.2
Fragaria					1.8	T
Lathyrus			1.7	0.1		
Ligusticum					1.8	0.1
Perideridae					3.5	0.4
Taraxacum	9.1	2.4	24.9	3.0	5.3	T
Tragopogon			0.6	T		
Trifolium	4.6	0.8	11.1	0.4		
Other			7.2	0.2	3.5	0.1
Insects						
Ants	22.7	0.4	22.1	0.5	5.3	T
Maggots			1.1	T	1.8	T
Tetraonidae	4.6	0.1				
Miscellaneous						
Debris	50.0	4.4	30.9	2.5	22.8	0.8
Garbage	4.6	T				
Pine needles					1.8	0.1
Unidentified root	9.1	0.1				
Animal						
Moose			0.6	T	3.5	T
Elk	4.6	T	5.5	T	15.8	0.5
N. pocket gopher			0.6	T		
Red squirrel			1.1	T	3.5	T
Ursidae			2.2	T		
Cervidae			1.1	T		
Unidentified Bird			1.1	T		

Trace (less than 0.1)

Table 28. Scat contents of all bear scats collected during the combined 1996-1997 period.

	Spring N=29		Summer N=87		Fall N=52	
Diet Item	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**	**% Freq.**	**% Vol.**
Whitebark pine	89.7	79.1	14.9	1.1	30.8	7.8
Fleshy Fruits						
Ribes					1.9	T
Sheperdia			2.3	T		
Vaccinium	3.4	0.2	2.3	T	1.9	0.1
Sporophytes						
Equisetum			6.9	0.3	5.8	0.2
Lycopodium			1.2	T	1.9	T
Grass/Sedge						
Agropyron					1.9	T
Carex			18.4	1.4	23.1	2.6
Deschampsia	3.5	T	1.2	T		
Juncus					1.9	T
Phleum			2.3	T	3.9	0.2
Poa			17.2	1.3	3.9	0.1
Other	10.3	0.1	8.1	0.7	7.7	0.2
Forbs						
Agoseris	3.5	0.1			1.9	0.1
Astragalus			2.3	0.1	3.9	0.1
Cirsium	3.5	0.1	9.2	0.8	9.6	0.8
Epilobium			16.1	2.6	13.5	1.3
Heraculum			3.5	0.3	1.9	0.1
Lathyrus			1.2	T		
Lomatium			2.2	0.1		
Osmorhiza			13.8	1.8	5.8	0.4
Stellaria			1.2	T		
Taraxacum	3.5	T	24.1	3.9	23.1	3.0
Trifolium			4.6	0.3	5.8	0.2
Other			2.3	0.1	5.8	0.8
Insects						
Ants	10.3	0.4	11.5	0.2	9.6	T
Miscellaneous						
Debris	13.8	6.0	12.6	0.6	3.9	0.1
Animal						
Mule deer			1.2	T		
Red squirrel					3.9	T
Ursidae					5.8	T
Cervidae	6.9	0.4	3.5	0.1		
Unidentified						
Bird			1.2	T		

Trace (less than 0.1)