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BROWN BEAR HABITAT PREFERENCES AND BROWN BEAR LOGGING AND MINING RELATIONSHIPS IN SOUTHEAST ALASKA

by
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Study 4.17
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SUMMARY

From July 1981 through June 1989, 95 brown bears were captured on Admiralty and Chichagof Islands and 4,059 relocations were recorded. Our sample of radio-collared bears included 30 males and 38 females from Admiralty and 9 males and 18 females from Chichagof. Bear density was estimated in a 344-km^2 area around the Greens Creek Mine on Admiralty Island using a replicate mark-recapture survey with radiotelemetry. The average density was 40 bears/100 km^2 during 1986-87. Replicate alpine trend counts were conducted on Admiralty in late June and early July from 1983 through 1988. The reproductive status of 57 radio-collared females on Admiralty and Chichagof was monitored from 1981 through 1989. Mean litter size of cubs of the year was 1.9. Cub mortality in the first year of life was 20%. Mean age at first reproduction was 8.1 years. The mean interval between successful litters was 3.9 years. Humans were the major source of adult bear mortality on Admiralty and Chichagof. Nineteen percent of marked bears were killed by humans during the study. The seasonal habitat use of radio-collared bears was described. Bear habitat use varied significantly among years and between sexes. Six adult females and 3 of their offspring never moved to coastal salmon streams during this study. We defined these bears as interior bears. Important habitats used by bears included upland old-growth forest, riparian old growth, estuarine grassflats, avalanche slopes, and alpine/subalpine. During late summer >55% of bear relocations occurred within the riparian zone although that habitat represented <5% of the total area. We suggest identifying riparian old growth as critical brown bear habitat. Relative to their availability within home ranges, clearcuts were avoided by bears on Chichagof Island. The average home range size for males and females on Admiralty and Chichagof Islands was 92 km^2 and 31 km^2, respectively. Most radio-collared bears were not displaced from habitually used salmon streams on Greens Creek during mine construction activities. However, bears appeared to adjust their movements within their home ranges. Preliminary management guidelines for development activities in brown bear range were developed as was a habitat capability model. Management implications of logging and mining on brown bear populations are discussed.

Key Words: Admiralty Island, brown bear, Chichagof Island, dens, density estimates, ecology, forestry, habitat capability model, habitat use, home range, logging, mining, mortality, old growth, reproduction, roads, southeastern Alaska, Tongass Forest, *Ursus arctos*.

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BACKGROUND

Once widely distributed across western North America, brown/ grizzly bear (Ursus arctos) populations have been greatly reduced in numbers and range as a result of habitat loss and human-induced mortality. In 1975, the brown bear was classified as threatened in the United States south of Canada. Alaska, with an estimated population of 30 to 40 thousand brown bears (Alaska Department of Fish and Game [ADF&G] 1978), remains the last stronghold of the species in North America. However, Alaska is not immune to the pressures which contributed to the bear's decline throughout its southern range.

Brown bears are indigenous to southeastern Alaska where they occur throughout the mainland and islands north of Frederick Sound. Although brown bears are still abundant throughout most of their historic range in Alaska's southern Panhandle, the most significant conservation problems facing the species in Alaska are first becoming evident here. For example, logging, mining, road construction, and back-country recreation are rapidly expanding throughout brown bear range in southeastern Alaska. To avoid or minimize population declines of this species, it is imperative that managers increase their knowledge of brown bear ecology, assess the effects of development activities on bear habitat and populations, develop techniques to monitor bear population trends, and develop management guidelines for habitat protection and human activity in brown bear country.

In 1981, ADF&G initiated a broad-based investigation of brown bear ecology in southeastern Alaska. The purpose of this study was to provide baseline ecological data on brown bear habitat relationships, seasonal distribution and home range characteristics, population parameters, and the potential effects of timber harvesting and mining on brown bear populations in southeastern Alaska.

STUDY AREA

Southeastern Alaska lies in a narrow band between the coastal mountains of British Columbia on the east and the Gulf of Alaska to the west. It extends from Dixon Entrance at the Canadian Border to Icy Bay 840 km to the north. Islands of the Alexander Archipelago compose much of the land area. Over 80% of this region lies within the Tongass National Forest (approximately 67,800 km^2). Study sites were selected on Admiralty (4,426 km^2) and Chichagof (5,341 km^2) Islands located in the northern portion of the archipelago (Fig. 1).

The topography of the area is rugged with mountains rising from sea level to over 1,400 m. The lowlands are dominated by a dense old-growth (in sensu Franklin et al. 1981, Schoen et al. 1981) rain forest of Sitka spruce and western hemlock (Picea sitchensis-Tsuga heterophylla). Broken rock, alpine tundra, and subalpine forest occur above 600 m. Interspersed throughout the forest are poorly drained muskeg bogs, avalanche slopes vegetated by deciduous shrubs, and numerous rivers and streams which provide spawning habitat for several species of anadromous salmon (Onchorynchus spp.) and are bordered by riparian spruce communities. Extensive wetlands dominated by sedge (Carex spp.) communities occur at the mouth of many streams.

A cool, maritime climate is characteristic of this region. Snow often accumulates at sea level during winter, and elevations above 600 m are covered by snow for 7-9 months of the year. Annual precipitation averages about 140 cm, and January and July temperatures average -6C and 13C, respectively (National Oceanic and Atmospheric Administration weather records).

The Sitka black-tailed deer (Odocoileus hemionus sitkensis) is the only ungulate and brown bears are the only large carnivore occurring on Admiralty and Chichagof Islands. Brown bears can be legally hunted in the study area from 15 September through 31 December and from 15 March through 20 May. Game Management Unit 4 includes the islands of Admiralty, Baranof, and Chichagof. The annual sport harvest of brown bears for that area from 1961 to 1987 has averaged 75 (ADF&G harvest records). In recent years, the defense of life or property (DLP) kill has increased.

The study site on northern Admiralty Island surrounds Hawk Inlet, the location of an abandoned cannery. The site includes a portion of the Mansfield Peninsula up to Funter Bay to the north and extends east to include the shoreline of Young Bay and Admiralty Cove and south to King Salmon River and Wheeler Creek. The southern region is located within the Admiralty National Monument, while most of Hawk Inlet, Admiralty Cove, and all of the Mansfield Peninsula are outside monument status. The study area (650 km^2) includes 80 km of marine shoreline and encompasses an extensive alpine ridge complex, 7 major river systems with spawning salmon, and numerous smaller streams. Within this larger area, we identified a smaller intensive site (344 km^2) surrounding Hawk Inlet and Greens Creek where we conducted aerial mark-recapture surveys. The survey area includes the Mansfield Peninsula south of a line between the head of Funter Bay and the mouth of Bear Creek and all the drainages into Hawk Inlet and Young Bay bounded on the east by Young Lake and Admiralty Creek and on the south by King Salmon River and upper Wheeler Creek to the saddle where these 2 drainages almost connect in Sections 29 and 30.

The major development activity within the Admiralty study site was the Greens Creek Mine which is now the largest operating silver mine in the United States. This world class hard rock mine also produces gold, zinc, and lead. Mineral exploration occurred during the early 1980's. Major road construction from tidewater to the mine site in upper Greens Creek was initiated in fall 1985 and mill construction began in 1987. The mine began industrial-scale production in 1989. Although there has been minimal logging in this area, much of the area outside the monument is scheduled for logging in the future. Admiralty Island was classified in 1986 by UNESCO as part of the Glacier Bay-Admiralty Island Biosphere Reserve.

The Chichagof Island study site (445 km^2) is located on the southeastern portion of Chichagof Island north of Peril Strait. It includes the watersheds of Trap Bay, Corner Bay, Kadashan, and Crab Bay draining into Tenakee Inlet to the north, and Basket Bay draining into Chatham Strait to the east. This site encompasses 72 km of marine shoreline, 7 major river systems with anadromous salmon runs, numerous other streams, and 5 major estuary systems. The topography of this area is more gentle and alpine habitat is less abundant than the Admiralty site. With exception of Kadashan, most of the watersheds within the Chichagof site have had extensive clearcutting. During this study, clearcuts ranged in age from 1 to 30 years. A logging camp with an open dump was located within the study area at Corner Bay.

OBJECTIVES AND METHODS

Because opportunities for observing bears inhabiting a dense rain forest are infrequent, radiotelemetry was chosen as the primary technique for monitoring individual bears. Most bears were captured in alpine habitat at about 750 m elevation by immobilizing them with a projectile syringe (0.04 mg/kg etorphine or 3.5 mg/kg phencyclidine hydrochloride) fired from a helicopter. A fixed-wing aircraft used with the helicopter helped locate bears and keep them in sight until immobilization was complete. Other bears were captured along beaches and anadromous salmon streams with Aldrich foot snares and then immobilized. Captured bears were instrumented with radio-transmitter collars (Telonics, Mesa, Ariz.), ear-marked with tags and colored flagging, and tattooed. A premolar was extracted for later age determination; sex, standard body measurements, and weight were recorded; and blood serum and hair samples were collected.

Radio-collared bears were monitored by radio-tracking from a fixed-wing aircraft (Helio Courier or Piper Super Cub). Our receiving system consisted of 2 H antennas (Telonics, Mesa, Ariz.) mounted under each wing and facing outward. These were connected to a TR-2 receiver and scanner through a right-left switch box. Movements, home ranges, and habitat use were determined by locating instrumented brown bears approximately once per week during daylight hours (generally between 0600 and 2100 hr). Bear locations were plotted on 1:63,360-scale topographic maps and habitat attributes were recorded from the aircraft while over the relocation site. In 9 telemetry trials, relocations averaged 24 m from the actual location (Schoen and Kirchhoff 1983). We estimated the accuracy of each relocation at the time of the telemetry survey. Class 1 relocations were within 10 ha and the habitat type was certain. Class 2 relocations were within 10 ha and the habitat type uncertain. Class 3 relocations were within 100 ha and habitat uncertain.

Study 1. To develop a 1986 and 1990 density estimate for brown bears within and adjacent to the Greens Creek Mine area. A modified capture-recapture technique (Miller et al. 1987) was used to estimate bear density in the study area. During the first half of July 1986 and again in 1987, replicate aerial surveys were conducted in the 344 km^2 study area centered on Greens Creek and the adjacent area (Appendix A). Marked bears were those with transmitting radiocollars. We planned to use this density estimate as the baseline density of bears in the development area. This estimate will be repeated sometime after 1990 and perhaps later (2000). Later estimates will allow quantification of population changes within the study area and testing the null hypothesis (H1) that brown bear density in Greens Creek and adjacent drainages is independent of mine site development and associated human activity.

Study 2. To develop and assess techniques for determining brown bear population trends, productivity, and recruitment. Replicate population trend surveys were flown in alpine areas annually, weather permitting, in late June and early July within the Hawk Inlet study area (approximately 344 km^2) and adjacent areas to the south. The southern area consisted of the drainages of Swan Cove, Pack Creek, and Windfall Harbor (approximately 300 km^2). Alpine surveys in the southern area were begun in 1987 to provide a control for assessing potential changes in the Greens Creek bear population as a result of mining. From these surveys we also determined cub:100 adult ratios. These data were compared with long-term productivity and recruitment data from marked females within the study area.

Study 3. To determine seasonal distribution, habitat use and preference, and, secondarily, to describe home range characteristics. Radio-collared bears on Admiralty and Chichagof Islands were monitored approximately once per week with relocations distributed throughout daylight hours. At each relocation the following habitat data were recorded: elevation; slope; aspect; terrain; habitat type; canopy coverage (%); spruce composition (%); timber volume; soil drainage; and closest distance to alpine, anadromous fish streams, coast, road, clear cut, and cover. Habitat variables are defined in Table 1. Distance measurements were not recorded until 1983. Seasons were defined as: spring (den emergence-15 May), early summer (16 May-15 Jul), late summer (16 Jul-15 Sep), and fall (16 Sep-denning). These are biologically meaningful periods in terms of bear distribution and activities.

Habitat use was considered equivalent to habitat preference following McLellan (1986). However, to identify potentially critical habitat (habitats used in much greater proportion than their availability) we compared habitat use to habitat availability. Home ranges were determined by connecting the extreme points of the set of relocations to form convex polygons (Mohr 1947). Areas of home ranges were calculated using a polar planimeter or computer digitizer.

The following hypotheses were tested in this study: H2, Brown bear use of specific landscape attributes is proportional to their availability within the study area; H3, Habitat use by bears does not vary seasonally; H4, Habitat use by bears does not vary between sexes; H5, Seasonal distribution and habitat use by bears is uniform within the population; and H6, Under natural conditions, adult brown bears remain faithful to their home range areas once they have been established. Differences in habitat use between seasons, sexes, and distributional status were tested by Chi-square contingency tables unless otherwise stated. Bears were considered to have used the same annual home range if ranges in consecutive years overlapped.

Study 4. <u>To assess seasonal brown bear habitat use of managed forests.</u> Radio-collared bears were periodically relocated by aircraft several times per day over several consecutive days on Chichagof Island during summer 1986. Our efforts were concentrated on bears whose home ranges overlapped areas of extensive timber harvest (e.g., those bears at Corner Bay, Kook Lake, and Crab Bay). Additionally, continuous 24-hour ground observations with a spotting scope and starlight scope were conducted in clearcuts on the Corner Bay road system several times during 1986. H7 that brown bear use of early successional forest types is independent of time of day was tested in this study. This study provided data on nocturnal use of clearcuts by bears--data not possible to obtain from aerial telemetry. This study coincided closely with Study 3 which provided data on seasonal use of clearcuts by radio-collared bears on Chichagof Island.

Study 5. <u>To determine natural mortality rates and major causes of mortality of brown bears.</u> Mortality rates were determined by monitoring known individuals through radiotelemetry.

Study 6. <u>To monitor plant phenology and chronology of salmon runs on Admiralty and Chichagof Islands.</u> This information was of a general and descriptive nature to help us interpret changes in seasonal distribution of radio-collared bears.

Study 7. <u>To identify den sites within forest denning habitat.</u> Where logistically feasible, we located (on the ground) and classified dens occurring in forest habitat.

Study 8. <u>To establish and annually monitor spring snow depth transects on the Admiralty study site.</u> Spring snow pack was monitored at Eaglecrest on Douglas Island and at several elevations on Robert Barron Mountain on Admiralty Island to determine if there was any relationship between spring snow pack and den emergence. This study included testing H8 that the chronology of spring den emergence by brown bears was independent of spring snow conditions.

Study 9. <u>To prepare a final report for the brown bear food habits study on Admiralty Island.</u> This was a University of Alaska Master's thesis by McCarthy (1989). The food habits of brown bears on northern Admiralty Island were studied through analysis of fecal samples collected in 1984 and 1985.

Study 10. <u>To monitor effects of intensive mine development activities on brown bear populations in and adjacent to the Greens Creek drainage of northern Admiralty Island.</u> This study assessed the effects of (1) road building and vehicle traffic, (2) aircraft traffic, (3) increasing human activity, and (4) garbage disposal on brown bear distribution and home range, den abandonment, human-induced mortality, and population density. Most of these effects were evaluated by monitoring radio-collared individuals and comparing predevelopment patterns with those during development. This approach was highly descriptive in nature because it is difficult to do experimental field work with brown bears. Changes in population density will be measured as described in Studies 1 and 2 above. This study will include testing the following hypotheses: H9, Habitat use by bears does not vary as a result of human activity; H10, There are no differences between bears denning in close proximity to mine development activities and bears outside the influence of those activities in their selection or abandonment of den sites; H11, Established home ranges and seasonal distribution of adult brown bears are independent of activities associated with road and mine development; and H12, The distribution and density of brown bear summer day beds along fish streams are independent of road-building activities.

Study 11. To develop preliminary management guidelines for intensive land development in brown bear range and assess the effectiveness of the guidelines in maintaining a natural and productive bear population in the study area. This was an ongoing process developed in close association with the ADF&G Area Management Biologist and the Greens Creek Mine Company. We assessed the success of our guidelines by our ability to (1) minimize changes in distribution and home range patterns of radio-collared bears, (2) minimize human-induced mortality on bears, and (3) maintain current population densities. This study coincided closely with Studies 1, 2, and 10.

Study 12. To evaluate an infrared scanning device for use in censusing bears in alpine/subalpine habitats, on grass-flats, and along fish streams. This was conducted during the latter part of August 1986 in cooperation with FLIR Systems Inc. of Portland, Oregon. The company provided an infrared scanner, which we mounted under the left wing of a Helio Courier H-250 aircraft, and a video monitor, which we carried in the rear cockpit. We evaluated our ability to identify bears by watching the monitor while in flight over our Admiralty study area where we knew the general locations of >10 instrumented bears.

Study 13. To evaluate techniques and assess the possibility of incorporating behavioral observation into a monitoring system for measuring early effects of development on bears. This project was exploratory in nature and conducted when favorable opportunities existed in conjunction with other studies. We utilized the expertise and advice of Dr. Robert Fagen, University of Alaska-Juneau, who is conducting behavioral research on bears at Pack Creek.

Study 14. To develop a habitat capability model displaying cumulative effects of intensive forestry and mining on brown bear populations in southeastern Alaska. This study required a final analysis and synthesis of data derived from the above studies. A manuscript describing the model was prepared in cooperation with biologists from the U.S. Forest Service (Appendix B).

Study 15. To revise and prepare a set of management guidelines for future development and human activities in brown bear range throughout southeastern Alaska. This will be accomplished in cooperation with Department management biologists and other experts where possible. This product will rely heavily on information gained from the exercise in Study 11 above.

Study 16. <u>To attend and participate in conferences and workshops.</u>

Study 17. <u>To summarize data and write reports including annual reports, a final report, and appropriate technical and popular publications.</u>

RESULTS AND DISCUSSION

This final report summarizes data collected from July 1981 through June 1989. During this period, 95 bears were captured on Admiralty and Chichagof Islands and 4,059 relocations were recorded.

On Admiralty Island, we captured 30 males and 38 females (Table 2). Of those 68 bears, 18 were recaptured once, 15 twice, and 1 4 times. Seventy-one percent of brown bear captures and recaptures on Admiralty were by helicopter, 14% by snares, and 15% by culvert trap or darting from the ground. On Admiralty Island, the age at first capture ranged from 1 to 23 years ($\bar{x}$ = 8.5, SE = 0.66). During this study, the ages of the oldest male and female were 20 and 29 years, respectively. We relocated 65 radio-collared bears 3,192 times on Admiralty Island during this period.

Twenty-seven brown bears, including 9 males and 18 females, were captured and radio-collared on Chichagof Island from 1983 through 1986 (Table 3). Seven of those bears were recaptured once. Fifty-six percent of the bears were captured with snares, 41% from a helicopter, and 3% by darting from the ground. The age at first capture ranged from 3 to 19 years ($\bar{x}$ = 7.4, SE = 1.2). Twenty-seven radio-collared bears were relocated 867 times on Chichagof Island.

<u>Study 1. Brown Bear Density Estimate for Greens Creek</u>

This study estimated the number of brown bears in a 344-km^2 study area around Greens Creek and Hawk Inlet on northern Admiralty Island. A manuscript describing this study has been prepared for submission to the Journal of Mammalogy (Appendix A). In summary, 9 replicate surveys were conducted over 2 years (1986, 1987), each taking 1.5-2.5 hours to complete. Estimates of brown bear numbers did not differ between years for all bears or bears >2 years old ($\underline{z}$-tests, $\underline{P}$ > 0.6). The average estimated number of all bears in the study area was 139. The average density within the 344-km^2 area was 40 bears/100 km^2 (1 bear/mi^2). This is the highest density of brown bears reported in the literature. The density of brown bears on Kodiak Island is closely comparable however (Barnes et al. 1988).

Extrapolating the point estimate of the average density for our study area to the entire 4,403-km^2 island results in an island population of 1,761 bears. Although there may be more productive sites on the island, our study area probably represents higher than average habitat capability for the island as a whole. Our best "guess" is that there may have been from 1,200 to 1,800 bears inhabiting the island in 1987.

This density estimate has provided us with a baseline density of the bear population influenced by the Greens Creek Mine. We now have an opportunity to replicate this estimate in future years and measure what, if any, effect the mine development has had on the resident brown bear population (H1). Our recommendation is that a new density estimate be conducted sometime after 1992 and again after the year 2000.

Study 2: Population Trends, Productivity, and Recruitment

Fourteen alpine surveys were flown during late June and early July in our northern Admiralty study site (Table 4). Survey flights averaged 1.8 hours and ranged from 1.0 to 2.6 hours. On average, our search intensity was 3 min/km^2 of alpine/subalpine habitat on Admiralty. Bears observed per hour ranged from 8.1 to 35.3 and averaged 25.0. We observed an average of 41 total bears on a survey flight, with a range of 22 to 67 bears. From 1983 through 1988, the mean annual cub:100 adult ratio was 51.7 (SE = 6.7, $\underline{n}$ = 6).

Four alpine surveys were flown south of our main study area during 1987 and 1988 (Table 5). Total bears observed and bears observed per hour were comparable with the northern study area. The mean annual cub:100 adult ratio was 33.7, substantially lower than the area to the north. We have no explanation for this lower rate but recognize our sample size in the southern area is low.

We believe that aerial bear surveys in alpine/subalpine habitat offer an efficient technique for estimating population trend. For this technique to be effective, however, it requires a knowledge of the seasonal distribution of bears and an abundance of alpine/subalpine habitat available to the population. We recognize that there are some areas in southeastern Alaska (e.g., southeastern Chichagof Island) where alpine habitat is not well represented. In those areas other population trend techniques must be developed (e.g., aerial infrared stream surveys).

We recommend that replicate ($\underline{n}$ >3) alpine surveys be continued annually in our northern Admiralty study area and the adjacent area to the south. This will provide an opportunity for continuing to monitor population trends of brown bears associated with the Greens Creek Mine development.

From 1981 through 1989, we had an opportunity to monitor the reproductive status of 57 radio-collared female brown bears on Admiralty (n = 39) and Chichagof (n = 18) Islands (Tables 6 and 7). This included 157 bear years on Admiralty and 53 bear years on Chichagof. The mean number of years female bears were monitored was 3.9 and 2.9 on Admiralty and Chichagof, respectively. The number of years monitored per bear ranged from 1 to 9.

The mean litter size for cubs of the year was 1.8 (SE = 0.10, n = 32) on Admiralty Island and 2.6 (SE = 0.24, n = 5) on Chichagof Island. The overall mean was 1.9 (SE = 0.10, n = 37). Our small sample size suggests caution in trying to interpret why litter sizes were higher on Chichagof than Admiralty Island. We believe that bear densities were substantially higher in the Admiralty study site. It is possible that adult predation on cubs may have been a factor in the smaller litter sizes on Admiralty. We have no evidence to suggest nutritional differences between the 2 sites. Cub mortality in the first year of life was 20% over both study areas; 24% for Admiralty (n = 46 cubs) and 0% for Chichagof (n = 10 cubs).

We recorded the age at first production of cubs for 6 bears on Admiralty and 1 bear on Chichagof (Tables 6 and 7). The mean age for first litter was 8.1 years (SE = 0.55). Two bears produced their first litter at age 10 but neither of those litters was successfully weaned. One bear produced her first litter at age 9; status of successful weaning was unknown. Four bears produced their first litters at age 7. Two of those litters were successfully weaned and the status of 2 was unknown. No females <7 years of age were observed to have produced cubs during this study. From 1981 through 1989, 21% of 7-year-olds (n = 14), 33% of 8-year-olds (n = 12), 45% of 9-year-olds (n = 11), and 92% of 10-year-olds (n = 13) had produced offspring.

During this study, the earliest age at first breeding resulting in production of a litter was 6 years. Two marked females were observed breeding at age 5; 1 bear did not produce any cubs the following year and the fate of the other is unknown. Other observed pairings included an 8-year-old and a 6-year-old; neither produced cubs the following year.

We had the opportunity to record the interval between successful litters (from weaning to weaning) for 8 females on Admiralty (including 2 intervals for 5 bears) and 1 female on Chichagof (Tables 6 and 7). The mean interval between successful litters was 3.9 years (SE = 0.21, n = 14) with a range of 3 to 6 years. It is important to point out, however, that several adult (>5 years) females failed to ever produce young during the period of observation. This included a 6-year interval for a female from age 5 to 10 years, a 5-year interval for a female from age 23 to 27 years (when she died of unknown causes), and a 5-year interval from age 14 to 18 years.

Several anecdotal observations of interest include the following. Two "interior" (Study 3) females (Nos. 6 and 14) were never successful in recruiting any offspring into the population. We monitored No. 14 for 8 years. She lost her first litter in the den during winter 1985. She did not emerge from her den until the second half of June. We found the remains of her cubs in scat inside the den. We speculate that due to the long denning period of nearly 8 months, the physical condition of both mother and cubs declined severely; the cubs died, and the mother ate them. In fall 1988, she was killed by a male bear and the fate of her litter of 2 yearlings was never discovered. Over a 9-year observation period, interior female No. 60 successfully weaned only 2 offspring from different litters (Table 6). From 1982 through 1986, female No. 56 was successful in weaning 2 cubs each from 2 separate litters. From 1986 through 1990, she lost 2 separate litters (see Study 10 for additional discussion).

Data presented here suggest that the productivity and recruitment of bears in southeastern Alaska, and particularly those on Admiralty Island, are lower than previously suspected. Although Admiralty has a high-density bear population, productivity may be comparable with some northern Alaska populations (Reynolds and Hechtel 1980). Additionally, there appears to be much variation among individual females in their productivity and success in recruiting offspring into the population. It is important to recognize the difference between an assessment of productivity from cub:100 adult ratios and the successful weaning and recruitment of offspring into the population. Perhaps in a high-density population like Admiralty Island many more cubs are produced than are successfully recruited. These considerations have significant management implications for bear conservation in southeastern Alaska.

Study 3. Seasonal Distribution, Habitat Use, and Home Range Characteristics

Seasonal distribution and habitat use:

Seasonal distribution and habitat use were determined from 3,874 relocations (Class 1 accuracy) of 65 and 26 radio-collared bears on Admiralty and Chichagof Islands, respectively, from 1981 through 1988. Six percent of the relocations occurred in spring, 30% in early summer, 48% in late summer, and 16% in fall.

We deferred testing H2 until we can accurately determine availability of habitat types using the Forest Service geographic information system. We rejected H3. Bear use varied significantly (Chi-square test, $P < 0.01$) among seasons for all topographic, vegetative, and distance variables except on Chichagof Island for distance to alpine ($P = 0.023$), distance to cover ($P = 0.044$), and distance to roads ($P = 0.110$). Due to our larger sample size (78% of relocations), longer study period, and better distribution of sexes in our Admiralty Island sample, we compared differences in habitat use between sexes only on Admiralty Island. We rejected H4 and H5. Seasonal habitat use by bears varied significantly (Chi-square test, $P < 0.05$) between sexes and distributional status except for differences between sexes during fall.

Spring--from den emergence through sea level green-up (late Mar-15 May). During this period, most bears (>80%) emerged from their high-elevation ($\bar{x}$ = 640 m, SE = 21, n = 84) winter dens. Males were the first to emerge and females with cubs of the year the last. Following den emergence, most bears remained at higher elevations for several days to a week or more, then began moving to lower elevations (<300 m). Some bears (<25%), however, remained at higher elevations throughout this period. The mean elevation of spring bear relocations on Admiralty and Chichagof Islands was 413 m (SE = 24.4, n = 178) and 328 m (SE = 50.3, n = 46), respectively. Forty-three and 54% of bear relocations occurred at elevations <300 m on Admiralty and Chichagof Islands, respectively (Table 8). On Admiralty, females were distributed at higher elevations ($\bar{x}$ = 478 m, SE = 30.4, n = 82) and steeper slopes ($\bar{x}$ = 22°, SE = 1.7) than males ($\bar{x}$ = 253 m, SE = 30.4, n = 79; $\bar{x}$ = 13°, SE = 1.3) ($P < 0.05$). This reflects female preference for higher, steeper den sites and the later den emergence of females than males (Schoen et al. 1987). We speculate that females search out more precipitous areas to avoid contact with males which are potential predators on cubs. During spring, radio-collared bears used a variety of aspects, and approximately 75% of bear relocations occurred on relatively smooth terrain (Table 8).

Upland old-growth forest received the greatest use (approximately 60%) of all habitat types available to bears on Admiralty and Chichagof Islands (Table 8). Most forest use occurred in well-drained, low- to mid-volume old-growth stands of <25% spruce composition with overstory canopies between 26% and 75% (Table 8). Other important spring habitats included avalanche slopes, riparian forests, subalpine forests, and estuarine grassflats. Bears were widely scattered during spring from sea level to the highest ridges. On Chichagof Island, clearcuts received 2% use. Spring foraging was focused on new growth of grasses and sedges along beaches, skunk cabbage roots (*Lysichitum americanum*) in riparian forests and wet meadows, and herbaceous vegetation on southfacing avalanche slopes.

During spring, from 50% to 60% of bear relocations were within 1.6 km of alpine habitat on Chichagof and Admiralty Islands, respectively, and approximately 60% were >1.6 km from the coast (Table 8). Most relocations (>60%) were approximately 5 km or more from anadromous fish streams (Table 8). Spring was a period of adjustment for bears as they came out of winter hibernation. Many bears appeared to be relatively lethargic (as their metabolic processes were not yet adapted to life outside the den) and not yet focused on active foraging in specific habitats.

Early summer--from end of sea level green-up through alpine green-up and the beginning of salmon runs (16 May-15 Jul). By early summer, most bears had emerged from their winter dens and passed through postdenning lethargy. Early summer is the peak of the breeding season in southeastern Alaska. During this time, radio-collared bears were widely distributed across both study areas and there was much variability in their habitat use. At the beginning of this period many bears were distributed at lower elevations where they concentrated their foraging on tidal sedges and herbaceous vegetation. By mid-June, most bears on Admiralty had moved to higher elevations (>300 m) while the majority of Chichagof bears remained at elevations <300 m. The mean elevation of bear relocations on Admiralty and Chichagof Islands was 550 m (SE = 11.6, n = 938) and 259 m (SE = 18.3, n = 214), respectively. Early summer distribution of bear relocations relative to slope, aspect, and terrain was similar to spring (Table 8).

Radio-collared bears on Admiralty Island were distributed higher during early summer than any other season except fall denning. This reflects their heavy use of alpine (28%), subalpine (15%), and avalanche slope (15%) habitats (Table 8). Over half of all bear relocations were distributed in open-canopy sites (<26% cover) and use of poorly drained scrub (<8 mbf/acre) and low-volume (8-20 mbf/acre) forests was relatively high (48%) (Table 8). As the snow pack receded at progressively higher elevations, bears moved up to forage on the new growth of succulent plants. By 1 July, most Admiralty bears were foraging extensively in subalpine meadows and avalanche slopes at elevations >600 m. Over 58% of all relocations of radio-collared bears on Admiralty were distributed <1 km from alpine habitat while more than 50% were >5 km from the coast during early summer (Table 8). Relocations of female bears on Admiralty continued to be distributed at higher elevations ($\bar{x}$ = 497 m, SE = 15.2, n = 469) and steeper slopes ($\bar{x}$ = 18^{o}, SE = 0.55, n = 469) than males ($\bar{x}$ = 451 m, SE = 21.2, n = 302; $\bar{x}$ = 16^{o}, SE = 0.65, n = 302).

Because Admiralty bears were concentrated in open alpine/subalpine habitats during early summer, we focused our aerial survey efforts there in late June and early July (Studies 1 and 2). All radio-collared bears on Admiralty Island used alpine/subalpine habitats at least sometime during this period. Forty-one percent of Admiralty bear relocations during early summer resulted in a visual sighting (Table 8). This was the optimal time for aerial surveys because bears were distributed farther from forest cover which resulted in the highest seasonal sighting rate.

Alpine/subalpine habitats received <8% use by radio-collared bears on Chichagof Island during early summer compared with 39% use by Admiralty bears (Table 8). This accounted for the greatest seasonal difference in habitat use between study areas. We speculate this was due primarily to the limited availability of high-elevation alpine/subalpine habitat on Chichagof Island. As a result, bears on Chichagof increased their use of old growth (41%), avalanche slopes (23%), and estuarine grassflats (16%) (Table 8). Clearcuts received 3% of early summer bear use on Chichagof Island.

Twenty-six percent of Chichagof bear relocations were distributed <0.2 km from the coast during early summer (Table 8). This reflects their high use of estuarine grassflats at this time. Chichagof bears also increased their use (43%) of areas within 500 m of anadromous salmon streams (Table 8). In general, pink and chum salmon entered streams 1-2 weeks earlier on the Chichagof site compared with the Admiralty site. Thus, by early July bears on Chichagof had already begun moving toward streams in search of fish, while Admiralty bears were still using high-elevation alpine/subalpine habitats.

<u>Late summer--the peak of riparian berry production and the major salmon spawning season (16 Jul-15 Sep)</u>. By late summer, most (86%) bears on Admiralty and all bears on Chichagof had moved to low-elevation coastal salmon streams. The mean elevation of bear relocations on Admiralty and Chichagof Islands was 194 m (SE = 7.9, $\underline{n}$ = 1,472) and 94 m (SE = 9.5, $\underline{n}$ = 404), respectively. The mean slope of relocations on Admiralty and Chichagof was 9° (SE = 0.27, $\underline{n}$ = 1,472) and 7° (SE = 0.54, $\underline{n}$ = 404), respectively. Seventy-six percent of bear relocations on Admiralty and 89% on Chichagof were distributed below 300 m (Table 8).

Interestingly, on Admiralty Island 14% of bear relocations were distributed above 600 m. Although most radio-collared bears on Admiralty were associated with fish streams during late summer, some females and their offspring remained in interior regions of the island. We called these individuals "interior" bears in contrast to "coastal" bears which moved to low-elevation salmon streams during late summer (Schoen et al. 1986). Throughout this study, 6 adult females and 3 of their weaned and radio-collared offspring (2 males, 1 female) exhibited an interior distribution.

While their radios were transmitting, none of the interior bears was ever located on a low-elevation salmon stream. One adult female was monitored for 1 year, 3 for 4 years, 1 for 7 years, and 1 for 8 years. The female offspring was monitored for 2 years and remained within her mother's home range throughout that time. The 2 male offspring were only monitored for 1 year each after they were weaned. Both remained in interior regions within their mothers' home ranges the year following separation. The following year, 1 male died and the other lost its radiocollar.

The mean elevation and slope of interior bear relocations on Admiralty during late summer was 657 m (SE = 20.0, $\underline{n}$ 187) and 23^{o} (SE = 0.8, $\underline{n}$ = 187), respectively. This was significantly higher and steeper ($\underline{P}$ < 0.001) than relocations of coastal bears ($\bar{\underline{x}}$ = 126 m, SE = 6.8, $\underline{n}$ = 1,285; $\bar{\underline{x}}$ = 7^{o}, SE = 0.2, $\underline{n}$ = 1,285). In fact, interior bears were distributed throughout the year at higher elevations than coastal bears ($\underline{P}$ < 0.001). Thus, we rejected our null hypothesis (H5) that habitat use is uniform throughout the population.

On 6 July 1983 and again on 17 August, 12 radio-collared bears were located intensively throughout a 24-hour period. In July, we flew at 1000, 1600, and 2200 hours, and again the next morning at 0500 hours. In August, we flew at 0800, 1400, and 2030 hours. In these intensive surveys, only 3 bears moved a maximum distance between points of from 3 to 6 km. Most bears moved only minimal distances (<1 km) within the 24-hour period. The 3 bears which made larger moves appeared to be just shifting location within their home ranges. We detected no major shift in habitat use related to time of day, nor was there a shift in distribution of either coastal or interior bears.

Interior bears represented 14% of our sample of radio-collared bears on Admiralty Island and relocations of interior bears represented 15% of our total relocations. Because coastal bears represented the majority of bears on Admiralty (86% of our sample), we have presented their seasonal habitat use separately (Table 9).

During late summer, bears on Admiralty increased their use of forest habitat (72%) with much of that use (40%) concentrated in riparian old growth (Table 8). Other important habitats used included avalanche slopes (10%), subalpine (7%), alpine (6%), and estuarine grassflats (5%). It is important to note, however, that there were significant differences ($\underline{P}$ < 0.001) in habitat use between coastal and interior bears on Admiralty Island. For example, coastal bears used upland and riparian old growth 25% and 54%, respectively (Table 9), compared with 10% and 5% for use of the same habitats by interior bears. Interior bears made much greater use of avalanche slopes (40%) and alpine/subalpine habitat (44%) than coastal bears (5% and 8%, respectively). Interior bears made greater ($P < 0.001$) use of open canopy sites on broken terrain in close proximity to alpine and at greater distances to the coast than coastal bears. The distribution of coastal and interior bear relocations relative to distance to anadromous fish streams varied significantly ($P < 0.001$). Sixty-six percent of coastal bear relocations occurred within 160 m of fish streams while 92% of interior bear relocations occurred beyond 800 m. Throughout the year, coastal bears used more forested habitats closer to the coast than interior bears which used more open alpine/subalpine habitats ($P < 0.001$).

During late summer, the diet of Admiralty Island bears was dominated by sedges, berries, herbaceous vegetation, and salmon. Salmon occurred in 42% of bear scats collected below 400 m and none of the scats collected above 400 m (McCarthy 1989). Scats above 400 m elevation were dominated by sedges and other plants, and 14% and 10% of scats included remains of deer and small mammals, respectively.

We believe the differential distribution of bears on Admiralty Island is a result of learned behavior as offspring follow their mother throughout her home range for 2 to 4 years. All 3 radio-collared offspring of interior females inhabited an area largely within their maternal home range after leaving their mother. Unfortunately, we were unable to continue monitoring the subadult male offspring for more than 1 year. However, we speculate that males eventually come into contact with the coast and salmon spawning streams as they disperse and their home ranges increase in size. This would explain why none of our adult males ($n = 15$) exhibited an interior distribution. In contrast, 18% of radio-collared females were interior bears as, we speculate, their mothers probably were.

It is unlikely that the extent of this differential distribution would have been determined without the methodology of radiotelemetry. During the late summer when most bears were using coastal salmon streams, the interior bears moved to habitats with low sightability, including old-growth forest (15% use) and avalanche slopes (40% use). Forty-eight percent of the relocations of interior bears were distributed below 600 m during late summer, lower than any other time of the year. A knowledge of differential distribution is important in designing sampling schemes for capture and survey work as well as assessing vulnerability to hunting and resource extraction activities.

On Chichagof Island, radio-collared bears used riparian old growth (55%) more than any other habitat type (Table 8). Other habitats used included upland old growth (20%), avalanche slopes (9%), subalpine (3%), and clearcuts (3%). Fifty-seven percent of Chichagof bear relocations were distributed within 1.6 km of the coast while 65% were distributed within 160 m of anadromous salmon streams.

During the late summer season, most bear activities were focused around salmon spawning streams on both Admiralty and Chichagof Islands. Fifty-seven and 61% of late summer bear relocations on Admiralty and Chichagof Islands, respectively, occurred within the riparian zone (Table 8). We defined the riparian zone as upland and riparian old-growth forest and inland stream habitat within 160 m of anadromous salmon streams. The riparian zone is characterized by high-volume spruce forests with >50% canopy closure. During late summer, radio-collared bears on both Admiralty and Chichagof Islands increased their use of high-volume (>30 mbf/acre) forest stands of >50% spruce composition and >50 canopy cover (Table 8). We estimated that 5% of our Admiralty study area was riparian zone habitat. The U.S. Forest Service estimated (using their computer GIS) the amount of old-growth spruce habitat to be 3.6% of the Chichagof study area. This is probably a close approximation of the amount of riparian zone habitat.

Major diet items which occurred in abundance in the riparian zone include several species of salmon, devil's club berries (Oplopanax horridus), salmonberries (Rubus spectabilis), currants (Ribes bracteosum), skunk cabbage, and other herbaceous vegetation. Numerous bear day beds were distributed throughout the riparian zone. In 1985, we counted 83 day beds along both sides of a 1.6-km strip of lower Zinc Creek and the east side of lower Greens Creek. The mean distance to the stream of the 83 day beds counted was 52 m (SE = 3.1). Eighty-eight percent of the beds were associated with live Sitka spruce or western hemlock trees with a mean dbh of 110 cm.

Heavily used bear trails were abundant throughout the riparian forest adjacent to streams in both study areas. We believe the dense forest provides important security cover which may allow more bears to coexist within this productive but densely populated habitat. Bear marking trees were commonly scattered along the trail system throughout the riparian zone. We speculate that the mark trees may enable the bears to avoid life-threatening intraspecific interactions. The dense cover of the riparian zone also provides bears with security and escape cover from humans using the same high-quality habitat.

The high bear use (>55%) of the relatively rare (<5%) riparian zone suggests a strong preference for this habitat on both Admiralty and Chichagof Islands during late summer. Because of their economic value for timber production these rare forest stands are also in high demand by the timber industry and have been harvested in much greater proportion than their occurrence within the forest. As a result of their limited distribution and importance to bears, we believe riparian forest stands adjacent to productive salmon streams should be considered critical brown bear habitat throughout the range of this species in southeastern Alaska.

Fall--from the end of the major salmon runs to winter denning (16 Sep-late Dec). By mid-September, most salmon runs in our study areas had declined, herbaceous vegetation had gone to seed, and peak berry production at sea level was finished. Consequently, most bears began moving away from coastal salmon streams toward higher elevations. The mean elevation of bear relocations on Admiralty and Chichagof Islands was 556 m (SE = 15.5, n = 432) and 210 m (SE = 17, n = 190), respectively. By fall, 75% and 30% of bear relocations were distributed above 300 m on Admiralty and Chichagof Islands, respectively (Table 8). Forty-six percent of Admiralty and 5% of Chichagof relocations occurred above 600 m. The higher elevational distribution of Admiralty bears reflects both topographical and biological differences in study areas as well as the occurrence of interior bears. The increased use of steeper slopes and broken terrain (Table 8) is indicative of a distributional shift toward higher, more dissected topography in both study areas.

Upland old-growth forest received the greatest amount of bear use during fall on both Admiralty (29%) and Chichagof (43%) Islands (Table 8). Avalanche slopes were next in importance receiving 25% use on Admiralty and 19% use on Chichagof. Bears in both study areas began moving out of riparian old-growth habitat in fall (Table 8). However, Chichagof bears made greater use (23%) of riparian habitat than Admiralty bears (12%). Unlike the Admiralty site, there were several late runs of coho and sockeye salmon which attracted bears throughout fall on the Chichagof site. On the Kadashan River, for example, several radio-collared male bears fished the late coho run well into December after the first snowfall. On Admiralty Island, 70% of bear relocations were distributed beyond 800 m of salmon streams compared with 46% on Chichagof Island. Other habitats used by bears during fall included subalpine forests, alpine, estuarine grassflats, and, on Chichagof Island, clearcuts (Table 8).

As bears moved away from salmon streams during fall, a higher proportion (>50%) of their relocations occurred beyond 1.6 km from the coast (Table 8). At the same time, a much higher percentage (75% on Admiralty, 33% on Chichagof) of relocations occurred within 1.6 km of alpine habitat. During this period, bears were observed foraging extensively on alpine and subalpine slopes for alpine blueberries (*Vaccinium* spp.) and on avalanche slopes for currants and devil's club berries. Annual herbaceous vegetation became unavailable in the high country (>600 m) following the first killing frosts in late September.

By early October, the first winter snowfall had usually settled on the alpine slopes, forage was becoming limited, and many bears began searching for winter den sites. In general, females began denning by the second week of October; by the end of October more than 70% were in dens (Schoen et al. 1987). Males began denning the third week of October, but by the end of October fewer than 50% were in dens. By mid-November, about 80% of the males and 95% of the females had denned.

Bears preferred steep (>30^{o}) broken terrain above 300 m for denning (Schoen et al. 1987). Fifty-two percent of all dens ($\underline{n}$ = 121) located occurred in old-growth forest habitat. Admiralty Island bears preferred subalpine forest and alpine/rock habitats and Chichagof bears preferred old-growth forest for denning. On Admiralty, rock caves were the most frequent den type located; on Chichagof, bears excavated dens most frequently under large-diameter Sitka spruce trees or in the bases of large snags.

Home range and movements:

The mean annual home range size for males and females on Admiralty Island was 100 km^2 (SE = 10.7, $\underline{n}$ = 46) and 37 km^2 (SE = 4.7, $\underline{n}$ = 81), respectively (Table 10). Mean annual home ranges for males and females on Chichagof Island were 85 km^2 (SE = 28.8, $\underline{n}$ = 11) and 25 km^2 (SE = 4.5, $\underline{n}$ = 28), respectively.

We did not statistically test the null hypothesis (H7) that adult bears remain faithful to their home ranges. However, we observed substantial overlap in consecutive annual home ranges of adult radio-collared bears. The greatest straightline movements (40-80 km) were made by 5 subadult males. Each of these individuals apparently established new home ranges distinct from their subadult or maternal home ranges.

Study 4. Habitat Use Within Managed Forests

From 1983 through 1986, we collected 854 relocations (Class 1 accuracy) from 27 radio-collared bears on Chichagof Island. During this period 24 relocations (2.8%) occurred in clearcuts (<31 years old) (Table 8). Of those relocations, 20 (83%) occurred in young clearcuts (<16 years old). The highest percentage use of clearcuts occurred in early summer (Table 8). Approximately 4% of the study area, or 2,365 ha, had been clear cut.

To better evaluate brown bear habitat selection relative to clearcuts, we compared use of clearcuts relative to their availability within the seasonal home ranges of radio-collared brown bears (Table 11). We divided the year into 2 seasons: den emergence through 15 July and 16 July to denning. Clearcuts were available within the seasonal home ranges of 16 bears. We estimated selection indices using a "Design III study with known availabilities" following McDonald (1990). We rejected the null hypothesis that use of clearcuts by bears was proportional to their availability within bear home ranges ($\underline{P} < 0.05$). Radio-collared bears avoided clearcuts in both the early and late season.

During the early season, 9 bears did not use clearcuts at all, 3 bears used clearcuts in greater proportion than their abundance within home ranges, and 1 bear used clearcuts in similar proportion to their abundance. No radio-collared bears were relocated in clearcuts >8% of the time.

During the late season, 8 bears failed to use clearcuts at all, 5 bears used clearcuts less than their abundance within the home range, and 1 bear used clearcuts in greater proportion than their occurrence within the home range (Table 11). All bears, except one, which used clearcuts used them <10% of the time. One bear, No. 88 (a young male), used clearcuts substantially (21%). This bear was habituated to humans and human food (it had been fed by several people at the Corner Bay logging camp). No. 88 was killed in defense of life when he entered the cookhouse at Corner Bay in 1986.

Aerial telemetry surveys were conducted during daylight. To assess the potential for nocturnal-diurnal differences in bear use of clearcuts, we conducted 24-hour ground observations (using a starlight scope during hours of darkness) of clearcuts in the Corner Bay drainage of Chichagof Island. During 131 hours of ground observations, 4 out of 15 bear sightings (27%) occurred in clearcuts, and none of those were during hours of darkness when survey flights are not possible (Table 12). We were unable to statistically reject H7 due to a low sample size. However, these data suggest that our aerial telemetry surveys (conducted between 0600 and 2100 hrs) have provided a representative sample of bear habitat use.

In over 20 hours of roadside surveys conducted during this same time period, only 4 observations were made of bears in clearcuts. An additional observation was made of a bear and her cubs walking several kilometers on a logging road to a garbage dump; another sighting of a single bear was made at the same dump. Throughout this period we accounted for a minimum known adult population of 9 bears (including radio-collared bears) within proximity of the roads and clearcuts under observation.

At the same time that the intensive 24-hour observations were being conducted, telemetry surveys were conducted periodically during daylight hours. Four radio-collared female bears were in the vicinity of our observation site. Of 28 relocations, 14% occurred in clearcuts, while the rest occurred in old-growth forests, avalanche slopes, or alpine/ subalpine. When a radio-collared bear was located in a clearcut, we spent up to 20 minutes circling at a distance which did not disturb the bear. On several occasions, bears were traveling through the clearcuts to a logging road, then following the road into forest cover. In other cases, bears moved through the clearcuts stopping frequently to feed on berries while traveling. During the salmon spawning season, bears concentrate in low-elevation (<300 m) valley bottoms. This is where most clearcuts are distributed in southeastern Alaska. Thus we expect that bears will be forced to travel through clearcuts even if they are not preferred foraging habitat.

Assuming that bears are intimately familiar with their home range and that habitat use reflects habitat preference (McLellan 1986), these data suggest that most bears on Chichagof Island are avoiding clearcut habitats throughout the year. We suspect brown bears make limited use of clearcuts because their quality as foraging habitat is not as high as that of other available habitats (e.g., alpine/ subalpine, estuarine grassflats, riparian old growth, and avalanche slopes). Those habitats have a greater abundance of succulent herbaceous forage and preferred fruits (e.g., salmonberry, devil's club berries, and currants) than clearcuts.

Compared with second-growth forests (30-150 years old), clearcuts in southeastern Alaska produce an abundance of shrub and herbaceous species (Wallmo and Schoen 1980, Alaback 1982). However, their production is relatively short-lived (<25 years). The impoverished understories of second-growth conifer stands in southeastern Alaska make them poor habitat for most wildlife species, particularly herbivores and omnivores like bears (Schoen et al. 1988). The standard timber rotation cycle in southeastern Alaska is 90 to 125 years. Because second-growth forests will dominate approximately 75% of the managed forest, the net effect of logging old growth in southeastern Alaska will be a long-term reduction in brown bear carrying capacity. Thus it is important that forest management plans consider the entire rotation period (approximately 100 years) to adequately evaluate the cumulative effects of clearcutting on bears.

The effects of forest management on brown bears, however, must also be evaluated in terms of bear-human interactions. Forest development in brown bear country (generally wilderness areas) significantly improves human access and consequently increases disturbances as well as direct human-caused mortality on bears. Roads increase the opportunity for human-induced mortality of bears through legal hunting, defense of life or property kills, and illegal killing (Knight 1980, Peek et al. 1987, Rogers and Allen 1987, McLellan and Shackleton 1988, Brody and Pelton 1989, Schoen 1990).

In southeastern Alaska, boats were historically used for brown bear hunting, and most of the bear harvest occurred along the shoreline. Thus, the interior of the islands were refugia separating many bears from humans. Within the last few years, however, that historical pattern has changed significantly. For example, over 200 km of logging roads have recently been built on the 1,000 km^2 northeastern peninsula of Chichagof Island, and over 600 km are scheduled to be built over the life of the timber sale.

The total kill of brown bears on northeastern Chichagof Island has increased substantially in recent years. From 1961 through 1969, the mean annual harvest of brown bears on northeastern Chichagof Island was 5.5 bears (ADF&G, unpubl. harvest data). Since 1980, during which time most road building and logging has occurred, the mean annual harvest (11.8) has more than doubled. In addition, from 1985 through 1988, the total harvest was 13, 15, 23, and 19 bears, respectively. K. Titus (unpubl. data) found a direct correlation (r = 0.93, $P < 0.001$) between fall brown bear kill and cumulative kilometers of road construction on northeastern Chichagof Island during the period 1978 to 1989. The hunting season for brown bears on northeastern Chichagof Island was closed by emergency order of the Alaska Department of Fish and Game on 30 September 1988. During that year, 6 of the kills were in defense of life or property; many were associated with garbage dumps around local communities or logging camps. Even in the absence of legal hunting, many bears will likely be killed in future control actions around rural communities and camps (particularly around garbage dumps), by deer hunters in defense of life, and by an unknown amount of poaching.

We received several reports of bears associated with logging camps being killed during this study. At Corner Bay Logging Camp, for example, 1 radio-collared male (which was reportedly being fed) was killed in defense of life when it broke into the cookhouse. We also received a confidential report by a camp resident at Corner Bay that one of our radio-collared subadult females (another bear which had been fed and frequented the dump) was shot and buried but never reported. At the Kennel Creek Logging Camp, also on Chichagof Island, someone went bear hunting at the dump and shot and wounded a bear. When people began looking for the wounded bear, they were charged by another bear which they had to kill. That bear had 2 cubs of the year. Thus 4 bears may have been eliminated around that dump. These anecdotes offer additional insights into the problems of increasing the interaction between bears and humans.

Study 5. Causes and Rates of Mortality

Twenty-eight percent of the bears captured (n = 95) on Admiralty and Chichagof Islands from 1981 through May 1989 died during the study (Table 13). This is a minimum estimate because the status of many bears was unknown as a result of radio failure or collars falling off. Four mortalities were due to capture immobilization. An additional capture-related mortality occurred as a result of a male bear killing and eating an estrous female before she had recovered from immobilization. Of the 22 mortalities not related to capture, 18 (82%) were human induced. These included 14 hunter kills, 3 defense of life or property kills, and 1 illegal kill. Thus 19% of our marked bears on Admiralty and Chichagof Islands were killed by humans over a 9-year period. Three bears died from unknown causes and 1 adult female with cubs was killed by a male bear.

In addition to the mortality of marked bears, 11 cubs of marked bears (20%) died in their first year of life. In one instance we had indirect evidence of adult male predation on cubs. We observed female No. 60 with 2 cubs of the year in spring 1983. The following week, we observed her in the presence of a male; her cubs were never observed again. She apparently came into estrus and bred that spring because the next spring she produced a new litter.

In October 1988 we observed a large, marked male bear carrying the body of bear No. 14 (a small 14-year-old female with 2 yearling cubs) over an alpine ridge. The male had apparently been feeding on No. 14 because we could see bloody tissue around her neck and shoulder area. We believe this was a very recent kill (<24 hr). We searched the area extensively for her cubs but did not find them nor did we ever see them again within her home range. We speculate that the male was preying on the cubs and the female was killed while defending them. Bear predation on cubs has been reported by Reynolds and Hechtel (1982) and Nagy et al. (1983).

The major cause of adult mortality of bears on Admiralty and Chichagof Islands is killing by humans. It is unlikely that cub mortality is directly caused by humans. We believe that adult predation on young may be the major cause of cub mortality.

Study 6. Plant Phenology and Chronology of Salmon Runs

As the opportunity permitted, we determined the approximate dates for the following phenological stages: bud break, flower, fruit, and leaf fall. This information was recorded periodically each year at Smuggler's Cove 20 km northwest of Juneau and intermittently during field trips to our Admiralty Island site. Generally, phenological development at the Admiralty site was approximately 4-6 days behind Smuggler's Cove. At Smuggler's Cove, the first green-up of skunk cabbage and beach rye (Elymus spp.) usually occurred in late March or early April. Cow parsnip (Heracleum lanatum) generally began to green up in early April and sedges in mid-April to early May. The fruit of blueberry and salmonberry began to ripen from mid-June to early July, while devil's club berries and currants did not ripen until mid-July and early August, respectively. These are descriptive observations and are not readily quantifiable. The original data sheets are on file at the Division of Wildlife Conservation regional office of ADF&G in Douglas, Alaska.

The average date of peak escapement for pink and chum salmon in Hawk Inlet on Admiralty Island was mid-August. The first fish generally entered streams in mid-July and fish often remained in streams through mid-September. Approximate date and average count of peak escapements for pink and chum salmon in our Admiralty and Chichagof study sites are on file with the Commercial Fisheries Division of ADF&G in Douglas, Alaska.

Study 7. Forest Denning Habitat

The denning ecology of brown bears on Admiralty and Chichagof Islands was described by Schoen et al. (1987). Of 121 brown bear dens identified, old-growth forest was the most common denning habitat (52%). Other habitats used included subalpine forest (13%), alpine (13%), rock (13%), and avalanche slopes (9%). For 63 den sites in old-growth forest habitat, spruce composition was 29%. This is higher than the average composition of <20% and may reflect a preference for denning under spruce trees compared with hemlock. Eighty-eight percent of old-growth forest dens occurred in commercial timber stands: 33% in low-volume (8-20 mbf/acre) and 8% in high-volume (>30 mbf/acre) stands. Noncommerical sites were used less and mid-volume sites more than their availability within the study area. Noncommercial forest sites were probably avoided because they occur on poorly drained sites with standing water.

We visited and classified 38 dens as to type. Twenty-four (63%) occurred in natural rock cavities, 8 (21%) were excavated in or under live trees or snags, 3 (8%) were excavated in earth, and 3 (8%) were surface beds. Cave dens were more common on Admiralty Island than Chichagof Island. Six of the 7 excavated dens on Chichagof were associated with large-diameter spruce trees or snags. On Admiralty, 2 of 4 excavated dens were under live trees. The mean dbh of these trees and snags was 99 cm (SE = 9.9, range 61-152 cm).

Tree ages were estimated at well over 200 years. Grizzly bear dens excavated under the bases of trees have been described as typical by Craighead and Craighead (1972) and Judd et al. (1986).

Our sample of visited dens was biased toward high-elevation, nonforested sites that were relatively easy to reach, but we did examine 14 dens within old-growth forest. Of those, 8 (57%) were excavated under the roots of old, large-diameter Sitka spruce trees or were excavated within the bases of snags with well-developed heart rot. We strongly suspect these are typical den sites within old-growth habitat.

In areas where bears den predominantly in old growth, extensive timber harvesting, particularly on steep slopes (>20^{o}) and at elevations above 300 m, could reduce the availability of suitable denning habitat. In this region where soil depth is shallow and torrential rainfall common, trees and snags may be important elements of excavated dens. It is unlikely that the second-growth stands replacing old growth would provide the large diameter trees and large snags with heart rot which brown bears prefer for forest dens. To minimize the loss of denning habitat as a consequence of logging in southeastern Alaska, we recommend avoiding logging on mid-volume, hemlock-spruce stands on slopes >20^{o} at elevations above 300 m in or adjacent to areas of brown bear concentrations.

<u>Study 8. Spring Snow Depths on Admiralty Island</u>

Spring den emergence of instrumented bears was monitored closely from 1982 through 1985. Mean dates of den emergence varied significantly ($\underline{P} < 0.001$) among years (Schoen et al. 1987). Early den emergence was correlated ($\underline{r} = 0.79$, $\underline{P} = 0.205$) with low annual snowfall above 425 m at Eaglecrest on Douglas Island (about 15 km east of the Admiralty study site) (Table 14). These data provide support for rejecting the null hypothesis (H8) that the chronology of spring den emergence by brown bears is independent of spring snow conditions. However, a larger sample size would be necessary to determine a statistically significant ($\underline{P} < 0.05$) relationship.

Because of the implications of early den emergence on the spring harvest of brown bears (Schoen et al. 1987), we established 2 sets of snow transects with northern and southern exposures on Robert Barron Mountain on northern Admiralty Island. Each of these transects has permanent snow stakes, established at 150 m intervals up to 760 m elevation, which can be observed from a low-flying aircraft. These transects were established during fall 1987. Annual snow accumulation data from northern Admiralty Island is on file with the Division of Wildlife Conservation regional office of ADF&G in Douglas, Alaska.

Study 9. Brown Bear Food Habits

The food habits of brown bears on northern Admiralty Island were reported by McCarthy (1989) as part of his Master's thesis at the University of Alaska-Fairbanks. The diets of interior bears and coastal bears were examined. Forage items observed in the diet of both groups were analyzed for nutrient content. While most bears used the protein-rich salmon resource, interior bears substituted deer, small mammals, and plant species and parts high in nitrogen. Both groups of bears appeared to seek a high energy diet during the fall pre-denning period. In the second phase of the study, captive brown bears were used in feeding trials to determine the digestibilities of 4 natural forages, sedge (*Carex lyngbyaei*), skunk cabbage, devil's club berries, and salmon.

Study 10. Effects of Mine Development Activities on Brown Bears

This study remains largely incomplete because the principal investigator terminated the study a year early to accept a new position. However, monitoring of the Greens Creek bear population is being continued under the direction of Dr. Kim Titus and assisted by LaVern Beier. The primary test of what effects the Greens Creek Mine development may have on this bear population will come as a result of testing H1 as described in Study 1. The baseline for that study has been established and additional density estimates will be completed in the next several years.

We offer the following general comments and observations as a result of our exploratory research conducted thus far. Gross habitat use (H9) does not appear to have changed substantially. However, a quantitative assessment remains to be done in the future.

To assess the effect of mine site development on denning bears (H10), we selected 6 female bears that had denned within 4 km of the mine site in upper Greens Creek (Schoen et al. 1987). Because of their proximity to the development area, we assumed these bears were most influenced by mine site activities, including intensive helicopter traffic. The mean distance these bears denned from the mine site the first year of observation was 3.4 km. They denned significantly farther from the mine site the next year ($\bar{x}$ = 11.7 km, $P < 0.05$).

We further assessed this relationship by comparing the mean distance among subsequent year's den sites for the 6 radio-collared females mentioned previously with that of 11 radio-collared females that denned outside the area of mine influence. The mean distance among den sites in subsequent years was significantly greater ($P < 0.05$) for the 6 bears that initially denned closest to the mine (10.4 km) than for the 11 bears outside the mine's influence (1.9 km). None of the radio-collared males denned near the mine site or within the Greens Creek drainage.

In general, it does not appear that home ranges and seasonal distribution (with exception of denning distribution described above) of most adult brown bears were substantially influenced in the short term by development activities (H11). The established home ranges of most bears (except for 2 adult males) continued to include areas used in previous years. Before road construction began along lower Greens and Zinc Creeks in fall 1985, we monitored 6 radio-collared bears (2 males, 4 females) in the lower Greens and Zinc Creek drainages during the late summer salmon season. By 1986, more bears had been captured and we were able to monitor 12 bears in the lower Greens-Zinc Creek drainage. These radio-collared bears included 5 females and 5 adult and 2 subadult males. One female and 1 male (Nos. 56 and 13) had been monitored in previous years.

During the 1986 late summer season, all marked bears, except 2 adult males, continued to use the lower drainage despite intensive road construction activity which included blasting and heavy equipment operation. Some bears were located within several hundred meters of construction activity. The 2 adult males infrequently traveled through the construction area. Instead, they used other salmon streams within their home range which were not influenced by construction activity. Intensive telemetry surveys conducted 3 times each day indicated that bears remaining in the lower Greens-Zinc Creek drainage shifted away from the immediate vicinity of construction activity and then moved in closer to the road when activity was reduced. We believe these bears remained in the area because this was their established home range and they were attracted to the abundant spawning salmon resource much like bears are attracted to any plentiful high-quality food resource. The forest apparently provided sufficient cover for them to remain in the area out of sight of humans. In our discussions with construction workers, we learned they rarely observed bears during the first 2 years of road construction work.

During the 1987 season, we monitored 13 radio-collared bears in the lower Greens-Zinc Creek drainage during late summer. One of the adult males (No. 98) which previously used this area avoided it in 1987. The other (No. 61) made limited use of the immediate construction area. We had an opportunity to monitor the distribution and movements of an adult female (No. 56) which we had been monitoring since 1982. This bear's annual home range remained relatively constant throughout the period 1982 through 1988. However, on a finer scale examination of her movements, we observed that she shifted her late summer intensive fishing activities several hundred meters from Zinc Creek to Greens Creek. As a result, several other female bears (Nos. 84 and 85) shifted their locations upstream on Greens Creek from the previous year. We do not know whether bear No. 56 moved because of disturbance or because of low salmon runs in Zinc Creek (salmon escapement in Zinc Creek was much lower in 1987 and 1988 than during previous years). These subtle changes in distribution would not be obvious without the means of radiotelemetry. However, they may have significant long-term ramifications for the stability of the population.

Bear No. 56 was the only radio-collared bear in the core development area of lower Greens-Zinc Creek monitored continuously from 1982 through spring 1989. Her reproductive history is interesting. We have direct evidence that she produced and successfully weaned 2 litters of 2 cubs each by 1986. She was observed with a single cub in spring 1987. She lost that cub sometime during that summer, fall, or winter because she was observed without cubs during 1988. She was captured in early summer 1989. At that time, she was without cubs but was lactating, suggesting she had recently lost her second consecutive litter. Although we have no direct evidence that development activities are implicated in her reproductive failure, we suggest the possibility that displacement from her familiar feeding area along lower Zinc Creek in 1987 may have reduced her reproductive effectiveness.

To further assess the effect of road-building activities on brown bear distribution, we measured use of summer day beds before and after road building. In November 1985, we identified 57 day beds and recorded their locations along a 1.6-km strip (approximately 120 m in width) on both sides of lower Zinc Creek. We used this day bed survey as a relative index of bear use in this area prior to road construction. On 15 October 1986, following major construction activities, we again conducted a day bed survey along that same section of Zinc Creek; however, we only counted 17 day beds (Table 15). Additionally, the proportion of day beds west of the creek increased substantially; more than half of the beds occurred there. We rejected our null hypothesis (H12) that the distribution and density of brown bear day beds along Zinc Creek were independent of year (i.e., road-building activity) (Chi-square test, $\underline{P} < 0.05$).

Many of the day beds identified during the second survey contained broken rock and debris from blasting during construction. Mean distance of day beds from the creek was 41 m (SE = 6.8) in 1986 compared with 52 m (SE = 3.1) the previous year. Although our day bed survey suggested bears avoided the streamside area adjacent to road development, our telemetry data indicated they remained in the lower Greens and Zinc Creek drainages. We think bears remained in their traditional home ranges but just shifted their movements away from active development.

Our observations of bears on the Greens Creek delta suggested that some (particularly subadult bears) were becoming habituated to aircraft and vehicle traffic noise associated with the mine development. On several occasions we suggested that construction workers avoid walking around the sedge meadow or upstream. One bear in particular (No. 79, a subadult female) became habituated to human presence. This bear was legally killed by a hunter (not associated with the mine) on the Greens Creek delta in September 1987.

To our knowledge, no bears were killed by construction workers or mine operators during this study. We attribute this initial success to a rigidly enforced garbage policy and camp guidelines prohibiting employees from carrying firearms, littering, hunting, or hiking on site. As a result, interactions between bears and humans were minimized and bears were not attracted to the camp facility. In the short term, then, we believe the direct impacts to bears have been minimized. As bears become more habituated to human presence, however, it will become more important to maintain or strengthen these rigid guidelines. The contrast between the bear problems encountered at the Corner Bay Logging Camp and at the Greens Creek Mine is dramatic. Greens Creek provides a good example of an effective camp policy for minimizing bear-human conflicts.

Finally, it is important to recognize that these results reflect short-term effects of development activities on bears. It would be premature to conclude that development of the Greens Creek Mine will have minimal impacts on the local brown bear population. Stage 2 of this project will continue to monitor radio-collared bears at Greens Creek as well as replicate the baseline density estimate. These data will provide additional and necessary information on which to evaluate the long-term effects of mine development on brown bears.

Study 11. Preliminary Management Guidelines

A review of the biological characteristics of brown bears provides an important perspective for assessing potential conflicts between bears and humans (Schoen 1990). Brown bears are an intelligent, long-lived (>20 yrs) species with a great capacity for learning. As a result of their relatively inefficient carnivore digestive systems, brown bears must exploit seasonally abundant, high-quality food resources. These characteristics often bring bears into contact with humans using the same productive lands. Once bears learn of a good foraging opportunity, it is difficult or impossible to discourage them from continuing to use the site. Brown bears are large-bodied animals capable of inflicting serious injury or death to humans. Thus, human activities which increase bear-human contact often result in bears being killed out of fear or in defense of life or property.

The following guidelines were developed in conjunction with research activities associated with the Greens Creek Mine development on Admiralty Island and logging activities at Tenakee Inlet on Chichagof Island. The objective of these guidelines is to reduce the impacts of resource extraction industries on brown bear populations in southeastern Alaska. The following guidelines emphasize managing human activities to reduce bear-human interactions.

Camp sites:

New construction for camp sites (permanent and seasonal) should never be located closer than 1.6 km from sites of seasonal brown bear concentrations (e.g., anadromous salmon streams, estuarine sedge meadows). In no instance should any existing camp or facility be located <0.8 km from a bear concentration area.

Food and solid waste:

Human activities and industrial camps located in brown bear habitat should comply with the current Alaska Department of Fish and Game policy on solid waste management including the following guidelines.

1. Solid waste disposal sites for communities and permanent field camps should be located, if feasible, in habitats receiving the least use by bears. For example, traditional movement routes and seasonal concentration areas (such as salmon spawning streams or productive berry areas) should be avoided.

2. The preferred alternative for disposal of organic products that may attract bears is incineration in a facility that meets DEC standards for combustion residue (i.e., <5% unburned combustibles). In large urban communities or at regional disposal sites, daily landfill is an acceptable alternative to reduce or eliminate attraction to bears, provided that these facilities are secured by a bear-proof fence. Existing open-pit sites that use surface burning for disposal should be phased out and replaced by a system of daily incineration meeting the above standards or by daily landfill.

3. Large (>15 people) permanent (>1 season) field camps should dispose of organic products by daily incineration in a fuel-fired incinerator that meets the above standards. Alternatively, organic products could be hauled daily to a DEC-approved regional disposal site. Temporary storage of

organic products prior to incineration or backhaul should be in a bear-proof enclosure (building or fence). These camps should be surrounded by a bear-proof fence. Alternatively, dining halls, kitchens, sleeping areas, and incinerators should be fenced, and no organic wastes allowed to be left in vehicles.

4. Small permanent facilities (e.g., lodges, weather stations) or large nonpermanent camps should daily segregate and store organic wastes and items such as cans and jars that are contaminated with organic waste in a bear-proof container for weekly backhaul to an approved disposal site. Alternatively, (1) organic waste and other combustibles could be incinerated in a locally fabricated incinerator meeting DEC standards for residue, or (2) garbage grinders with disposal to a sewer system could be used to remove organic wastes, while contaminated combustible and noncombustible wastes could be incinerated or temporarily stored as above.

5. Food and organic wastes, if stored outside in bear habitat, should be stored in sealed bear-proof containers. Although it is not necessary to remove fish or game carcasses from the field, these should not be left at a central site nor should they be left in or near a campsite or other place with high potential for bear-human conflicts.

6. Small groups of people using Alaska's backcountry should burn all combustibles and pack out all noncombustibles. Organic material should not be discarded along trails. Caution and common sense are required to reduce or eliminate attractants to bears.

7. In all new parks, roadside facilities, and temporary construction worksites located in bear habitat, bear-proof garbage cans and regular garbage pickup should be required. This requirement should be phased into all existing facilities as soon as possible.

8. Baiting and feeding bears and other wild game by photographers, tourists, hunters, or others is prohibited except for trapping furbearers or hunting black bears consistent with regulations on black bear baiting.

9. Bears currently accustomed to eating garbage should be handled on a case-by-case basis according to ADF&G's guidelines for managing bear-human conflicts.

Firearms:

In large industrial camps (e.g., logging and mining camps), camp policy should discourage the carrying of personal firearms by all employees except foremen and security personnel.

Hunting, fishing, and backcountry recreation:

Hunting by industrial camp personnel should be prohibited by camp policy at or near the camp site while employees are on duty status. Fishing along anadromous salmon streams should also be discouraged in areas of seasonal bear concentrations. Hiking, berrypicking, photography, and other outdoor activities should be minimized outside the camp compound and particularly in areas of seasonal bear concentrations.

Feeding bears and littering:

Attracting and habituating bears to human foods is one of the most significant causes of bear-human conflicts. It is illegal to feed bears. This should be a strictly enforced camp policy punishable with termination (see solid waste policy above). Camp policies should also clearly prohibit leaving foods or other bear attractants in the field or work area. This policy needs rigorous enforcement.

Road construction and access:

Road construction in brown bear habitat should be minimized. Construction of roads should be avoided <1.6 km near important seasonal concentration areas (e.g., anadromous salmon streams, berry fields, estuarine sedge flats). Where road construction in bear habitat is unavoidable, public and recreational access should be prohibited and strictly enforced. When roads are no longer necessary, they should be permanently removed or made impassable to motorized vehicles.

Habitat impacts:

Construction of industrial facilities and recreational or homesite developments should be avoided in areas of seasonal bear concentrations (e.g., anadromous salmon streams, estuarine sedge meadows, riparian forests). Short-term intensive human use of sites of seasonal bear concentrations should be scheduled to avoid peak periods of bear use. Logging of riparian old-growth forest adjacent to anadromous salmon streams should be avoided within 150 m and prohibited within 30 m of the streamside.

Harassment of bears:

Bears should not be harassed or chased by motorized land vehicles or aircraft. Bears should be approached no closer than 150 m and 300 m by fixed-wing aircraft and helicopters, respectively.

Bear-human conflicts:

ADF&G has developed a policy for dealing with bear-human conflicts. This policy emphasizes the prevention of conflicts through public information, reducing attractants (e.g., food, garbage), and nonlethal deterrence. In cases where immediate danger to an individual or his property exists, offending bears may be killed by any individual under provisions of the DLP regulation (5 AAC 92.410). This regulation should be employed only as a last resort. If a bear is killed under DLP provisions, and the taking was brought about by improper garbage or a similar attractive nuisance, the offender will be warned or cited. It is not legal to kill a bear under the DLP regulation to protect a hunter-killed game animal.

Education:

All industrial camps and other facilities (e.g., lodges, fish camps, hatcheries, tour groups, research and exploration camps) should routinely provide bear safety education to their employees. This can be accomplished by inviting wildlife managers from state or federal agencies to periodically speak to camp staff or by using educational material being developed by those agencies. Bear safety programs should emphasize camp sanitation, basic bear biology and behavior, how to avoid contact with bears in the field, and what to do in case of a bear encounter.

Study 12. Evaluation of Infrared Scanner

We flew 2 flights, early morning (0530 hr) and late afternoon (1500 hr), over the Admiralty study area during August 1986. We had significant difficulty picking out animals (both deer and bear) during the afternoon flight. The thermal image of individual animals was difficult to distinguish from the background image of other environmental features including rocks, stumps, and logs. During the early morning flight, however, we were successful in discriminating between individual animals and the background environment. We easily distinguished a female bear and 2 cubs walking across a stream in the riparian forest of Greens Creek. We also observed several other bears on the beach and within the riparian forest. Later, we flew alpine habitat where we easily identified many deer, several of which we would not have located visually.

We believe there is good potential for monitoring brown bears in coastal Alaska with an infrared scanner mounted on an aircraft. This device can be used at night or early morning (when the greatest thermal differential exists) in alpine areas, on tidal wetlands, or along anadromous salmon streams. To gain maximum effectiveness, however, the scanner should be mounted on a helicopter or a fixed-wing aircraft equipped with a gyro mount. This would allow better tracking along a winding stream system. Utilizing an infrared scanner to fly bear surveys along fish streams in August would provide a good alternative to early summer alpine surveys in areas where alpine habitat is limited. We recommend additional testing of this technique in association with radiotelemetry in one of the intensive brown bear study sites in southeastern Alaska.

Study 13. Behavioral Observations

This study was incidental to other activities and occurred on an opportunistic basis. Conducting behavioral observations is very time intensive and our opportunities to do so were relatively limited and concentrated at the Greens Creek delta in Hawk Inlet on Admiralty Island. We observed bears from a tree blind located on a small intertidal island overlooking the sedge meadow between Greens Creek and Zinc Creek. The most productive observation periods were primarily during early morning and late evening in August and early September when salmon were spawning in the streams, and secondarily in May and early June when bears were feeding on the new succulent growth of sedges.

Our data were insufficient to quantify any significant trends in behavior. However, some opportunities appear worthy of further work and several generalizations can be made from our limited observations.

Our general observations (unpublished field notes) indicated that up to 14 individual brown bears used the sedge meadow of the Greens Creek delta at one time. The most intensive use of this area occurred in the evening hours around dusk. Based on the number of instrumented bears (13) regularly using the lower Greens Creek drainage (approximately 5 km in length) and our average sightability (29%) of marked bears, we estimate there may have been greater than 40 brown bears using the Greens Creek and Zinc Creek drainages and adjacent vicinity during the peak of the salmon run. The bears observed using the meadow area most frequently were subadult bears. Our visual observations, combined with telemetry relocations on Greens and Zinc Creeks, indicate that older dominant bears make greater use of riparian forest cover upstream from the sedge meadow. Compared with other bears, adult males were seen less often using the open meadow, except during the breeding season (May-Jun) when receptive females were present. These data suggest the meadow may be inferior habitat during daylight hours due to lack of security cover.

The bears that commonly used the sedge meadow of the Greens Creek delta used it in a traditional manner, generally leaving and entering the forest at the same location and traveling a familiar circuit around the delta and streams.

Most bears using the meadow area appeared to be habituated to high-flying aircraft, vehicle traffic on the Greens Creek road, and boat traffic in Hawk Inlet.

The most frequent activities observed on the Greens Creek Delta were traveling, grazing, and fishing. Bears are highly individualistic. Fishing was an activity in which we observed great variation among individual bears in fishing technique and success. Some bears were highly skilled while others were relatively inefficient. We also observed substantial differences in the general demeanor of individual bears. Some, for example, were very timid and rarely moved more than a few meters from cover while others were more aggressive and frequently wandered several hundred meters from cover. When the meadow area was used by females with cubs, the mothers were much more nervous and interrupted their foraging more frequently than single or subadult bears, and females seldom let their cubs wander more than 20 m away. Compared with bears at the Pack Creek viewing area on Admiralty Island, our observations suggest that Greens Creek bears were more vigilant and secretive, played less, spent less time away from cover, and were less habituated to humans.

We believe there are many subtle intraspecific interactions taking place in local brown bear populations. As land management intensifies in southeastern Alaska and concern over brown bear conservation increases, a better understanding of bear behavior and intraspecific relationships may provide new tools for the management and conservation of the species. We recommend continued efforts be made toward increasing our knowledge of the behavior of coastal brown bears. We believe there may be some valuable research opportunities in contrasting the behavior of bears among areas like Greens Creek, a site of industrial development; Pack Creek, a viewing area with habituated bears protected from hunting (Fagen and Fagen 1990); and 1 or several undeveloped watersheds with similar high-density brown bear populations.

Study 14. Habitat Capability Model for Brown Bear in Southeastern Alaska

Habitat capability models are required for each management indicator species (including brown bears) on the Tongass National Forest. We assembled an interagency team of biologists and developed a habitat capability model using our data base on brown bear habitat use from Admiralty and Chichagof Islands. Each of 20 habitats is assigned a habitat capability value based on habitat preference or best professional judgment. The effects of human activity and resource development on brown bears were estimated, based on best professional judgment, as reductions in habitat capability within zones of human influence. This model is the culmination of much of the research described within this final report and is presented in its entirety in Appendix B.

Study 15. Revision of Management Guidelines

This study will be deferred until the next phase of brown bear research is completed in southeastern Alaska. Preliminary guidelines prepared in Study 11 will be incorporated into routine management where appropriate and their effectiveness evaluated through continuing research and management activities.

Study 16. Conferences and Workshops

We have participated in 11 formal conferences and workshops since initiation of this research project. These included 3 International Conferences on Bear Research and Management; 3 Alaska Interagency Bear Workshops; the Grizzly Bear Habitat Symposium in Missoula; the interagency Habitat Futures Workshop in Victoria; the Alaska Environmental Assembly in Juneau; the Second Glacier Bay Science Symposium in Gustavus; and an invited paper on Forest Management and Bear Conservation will be presented at the V International Congress of Ecology in Yokohama, Japan. We have also cooperated with the National Geographic Society and the National Audubon Society in their productions of grizzly bear television specials, and have presented numerous public interest programs on bear safety, biology, and natural history.

Study 17. Reports and Publications

In addition to 7 progress reports and this final report, we have prepared 7 professional papers (Appendix C), 3 popular articles, and currently have 5 papers in various stages of preparation.

MANAGEMENT IMPLICATIONS

The northern islands of southeastern Alaska, particularly Admiralty Island, support some of the highest density brown bear populations in the world. Mark-recapture density estimates incorporating radiotelemetry provide a repeatable technique for measuring population changes over time. The 1986-87 density estimate of 40 bears/100 km^2 in the Greens Creek area provides a baseline from which to measure bear population response to the Greens Creek Mine development. Replicate alpine surveys may also provide an efficient technique for monitoring population trend.

Coastal brown bears in southeastern Alaska (particularly on Admiralty Island) appear to have relatively low reproductive rates, comparable with interior and northern grizzly bear populations. Low recruitment of young into the population may have significant implications for population sustainability if adult mortality increases. Humans were the most significant cause of adult bear mortality on Admiralty and Chichagof Islands. Because bears are long-lived and are difficult and expensive to census, it may take years of overexploitation before a serious population decline is detected. Once identified, population declines may be difficult to reverse because brown bears have such low productivity.

In southeastern Alaska, we observed significant differences in brown bear habitat use among individuals and seasons and between areas. Knowledge of such differences will be important in developing research and management programs. Seasonally important habitats used by bears included upland old-growth forest, riparian old growth, estuarine grassflats, avalanche slopes, and alpine/subalpine meadows. Riparian old growth is very limited in abundance throughout southeastern Alaska. However, when adjacent to anadromous salmon streams, these stands are used extensively by bears for feeding and cover during the important late summer season. For these reasons, riparian old growth should be classified as critical brown bear habitat in southeastern Alaska.

Denning chronology of brown bears in southeastern Alaska varies annually and between sexes. We believe spring snow pack influences the timing of emergence from dens. Females leave dens later in spring than males. The spring bear harvest also varies substantially among years. Following a late spring with higher than average snow pack above 400 m elevation, fewer bears, particularly females, are likely to be harvested.

Under natural conditions, availability of denning habitat does not appear to be a limiting factor for brown bear populations in southeastern Alaska. To minimize loss of denning habitat as a consequence of logging, we recommend avoiding logging on mid-volume, hemlock-spruce stands on slopes >20^{o} at elevations >300 m in or adjacent to areas of known brown bear concentrations.

Once established, home ranges of adult brown bears remain relatively stable over consecutive years. Most radio-collared bears were not displaced from their home ranges by construction activity at Greens Creek. However, disturbance resulted in subtle shifts within the home range. We suggest this may increase intraspecific interactions and reduce reproductive success. This remains a topic for further investigation. If development occurs in watersheds with high-denisty bear populations and bears are not displaced, the opportunity for bear-human encounters will increase.

Industrial-scale logging and mining are increasing throughout southeastern Alaska. Both have the potential for significantly influencing brown bear populations. Extensive clearcut logging in southeastern Alaska is converting productive old-growth habitat to early successional forests of lower value for brown bears. In addition to direct habitat loss is the problem of habitat fragmentation as large tracts of old growth are cut into smaller, more isolated patches with more roads, increased human access, and bear-human interactions. As a result, more bears will be killed legally by hunters, in defense of life or property, and illegally. Only legal hunting can be effectively managed.

In the last 3 decades, timber harvest on the Tongass Forest in southeastern Alaska has been concentrated in the relatively rare high-volume (>30 mbf/acre) old-growth stands. Valley-bottom riparian spruce stands are preferred by the industry because of their high economic value. During late summer, brown bears concentrate in these same riparian sites, identified as critical brown bear habitat. Logging these stands will not only reduce long-term carrying capacity for brown bears, it will also result in more bear-human interactions and inevitably lead to increased bear mortality.

Hard-rock mining in southeastern Alaska has the same potential as logging for increasing bear mortality. However, because mining is much more localized in scope, human activity can be more easily managed and direct impacts on habitat should be less extensive than logging. Both development activities have the potential for reducing the biological productivity of salmon streams which could directly impact brown bears.

Although Alaska remains the last stronghold of the brown bear in North America, many of the same factors that led to their extirpation throughout most of their former range in the contiguous United States are also occurring in southeastern Alaska. Bears are species of landscapes rather than habitat types per se. Human activities and land uses must be factored into bear habitat relationships. Road construction and forest clearing are two of the most serious threats to brown bear populations throughout their range. Resource managers must begin comprehensive, long-term planning. An understanding of the processes of habitat fragmentation and population extinction is necessary for maintaining viable bear populations in the face of increasing habitat destruction and isolation.

To minimize the impacts of resource development on brown bear populations in southeastern Alaska, emphasis should be placed on comprehensive long-term planning, protecting riparian old growth adjacent to anadromous salmon streams, protecting some complete watersheds (as critical refugia) from major development, minimizing new road construction, requiring fuel-fired incinerators in all camp facilities, developing conservative hunting regulations, population monitoring, and educating the public about the special requirements of bears.

Large expanses of undeveloped productive habitat with minmal human intrusion is of primary importance for long-term brown bear conservation. We consider bears to be a flagship species for the wild ecosystems they inhabit. Our success at conserving brown bears of the old-growth rain forest will require long-term planning and cooperation, and will likely depend more on our skill as educators, creative people managers, and landscape architects than on wildlife management per se.

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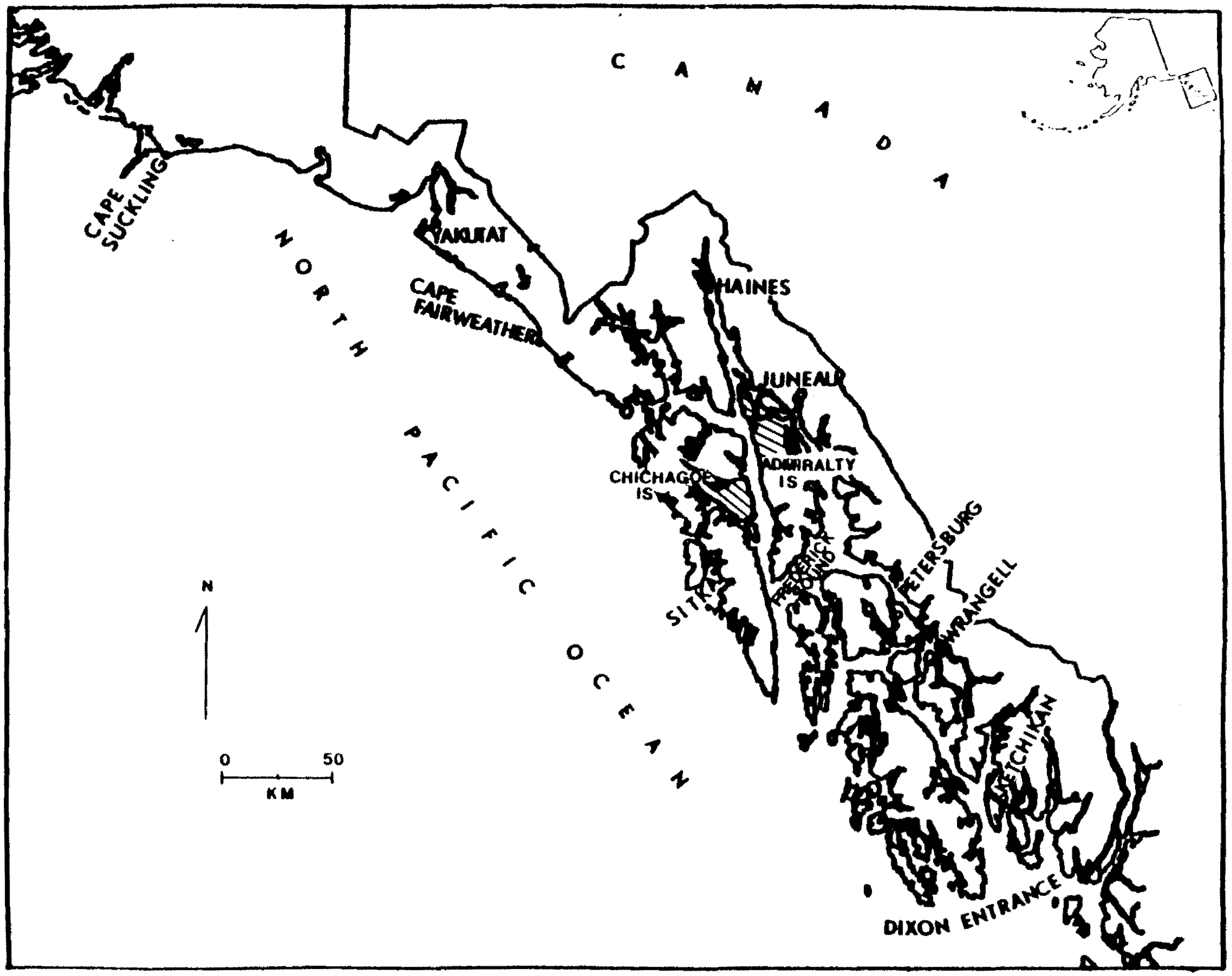

Fig. 1. Location of brown bear study sites (cross-hatched areas on map) on northern Admiralty and southeastern Chichagof Islands, southeastern Alaska.

Table 1. Description of habitat types used in analysis of seasonal distribution of radio-collared brown bears on Admiralty and Chichagof Islands, Alaska.

Habitat type	Description
Upland old-growth forest	Old-growth forest between the beach/estuary and subalpine, excluding riparian forest
Riparian old-growth forest	Old-growth spruce forest with salmonberry-devil's club understory adjacent to streams
Subalpine forest	Subalpine zone forest (>600 m) and meadow dominated by mountain hemlock
Alpine tundra	Alpine zone heath meadows above treeline
Alpine rock	Broken rock above 600 m
Avalanche slope	Recurrent slide zone above 300 m
Estuarine grassflats	Vegetated portion of an estuary below mean high water, dominated by _Carex_ and _Elymus_
Clearcut	Young forests (<25 years old) originating from clearcut logging
Other	Miscellaneous habitats (e.g., muskeg, second-growth forest, ice fields, lakes, roads, and other developed areas)

Table 2. Summary and status of brown bears captured on Admiralty Island, fall 1981 through 30 June 1989.

Bear No.	Location	Capture (recapture) Sex	Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Status 6/30/89
51	Greens Creek	M	1	60	8/28/81	S	Radio lost 9/81
60	Greens Creek	F	20	160	9/21/81	H	--
60	Greens Creek	F	21	135[d]	7/2/82	H	--
60	Greens Creek	F	24	125[d]	7/8/85	H	--
60	Greens Creek	F	25	125	7/3/86	H	--
60	Greens Creek	F	26	163	6/28/87	H	Transmitting
59[e]	Greens Creek	M	3	80	9/21/81	H	--
59[e]	King Salmon	M	5	113[d]	5/1/83	H	Mortality
58	Eagle Peak	M	4	180	9/21/81	H	--
58	Hawk Inlet	M	5	194	8/8/82	S	Last sighted 9/84
36	Mansfield Peninsula	F	14	230	9/26/81	H	Radio lost 5/82
50	Greens Creek	M	3	120	9/26/81	H	--
50	Greens Creek	M	5	146[d]	6/17/83	H	Radio lost 5/85
14	Greens Creek	F	7	120	9/26/81	H	--
14	Greens Creek	F	8	90	7/2/82	H	--
14	Greens Creek	F	11	95[d]	7/8/85	H	Bear kill 8/88
B-14	King Salmon	F	2	100	9/26/81	H	Mortality
43	King Salmon	F	15	250	9/27/81	H	--
43	Greens Creek	F	20	114	7/3/86	H	Transmitting
6	King Salmon	F	8	150[d]	9/27/81	H	--
6	Wheeler Creek	F	10	153	6/14/83	H	Radio lost 5/86
62	Young Bay	F	14	150	6/16/82	S	Last located 9/86
10	Greens Creek	M	11	280[d]	7/2/82	H	--
10	Greens Creek	M	13	288[d]	7/6/84	H	--
10	Hawk Inlet	M	15	315	6/9/86	S	Radio lost 5/87
38	Greens Creek	F	23	280	7/2/82	H	--
38	Greens Creek	F	26	180[d]	7/8/85	H	Found dead 5/86
99	Greens Creek	F	17	200	7/8/82	H	--

Table 2. Continued.

Bear No.	Location	Capture (recapture) Sex	Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Status 6/30/89
99	Greens Creek	F	19	158	6/21/84	H	Radio lost 9/85
95	Mansfield Peninsula	F	8	170	7/8/82	H	--
95	Mansfield Peninsula	F	14	200	9/16/88	H	Transmitting
72	Eagle Peak	M	6	200	7/8/82	H	Last located 9/86
34	Mansfield Peninsula	F	2	70	7/8/82	H	Hunter kill 9/83
63	Greens Creek	F	17	160	7/8/82	H	Last located 10/84
20	Greens Creek	M	5	100	7/30/82	S	--
20	King Salmon	M	6	135	5/1/83	H	Mortality
56	Greens Creek	F	13	170	7/30/82	S	--
56	Greens Creek	F	16	158[d]	7/8/85	H	Transmitting
48	Greens Creek	M	Ad	300	8/3/82	S	Radio lost 6/83
39	Mansfield Peninsula	F	9	270	8/7/82	S	--
39	Mansfield Peninsula	F	12	171[d]	7/9/85	H	Transmitting
37	Mansfield Peninsula	F	10	270	8/3/82	S	Hunter kill 10/83
67	Greens Creek	F	2	60	8/2/82	S	No radio
7	Pack Creek	F	11	150	8/26/82	D	No radio
11	Pack Creek	M	4	120	8/28/82	T	Hunter kill 5/83
8	Pack Creek	F	10	150	8/26/82	T	--
8	Pack Creek	F	16	120	7/19/88	D	Removed radio
9[f]	Pack Creek	F	1	54	8/26/82	D	No radio
91	Pack Creek	F	19	162[d]	6/21/83	H	?
92	Pack Creek	F	16	158[d]	6/21/83	H	Radio lost 5/86
93	Pack Creek	M	5	158[d]	6/21/83	H	--
93	Pack Creek	M	10	170	6/27/88	H	Removed radio
94	Pack Creek	F	10	156[d]	7/13/83	T	--
94	Pack Creek	F	15	114	7/19/88	D	Removed radio
40	Greens Creek	M	10	180	6/21/83	H	Last located 8/85
13	Greens Creek	M	15	284[d]	6/14/83	H	--
13	Greens Creek	M	16	270[d]	7/6/84	H	--

Table 2. Continued.

Bear No.	Location	Capture (recapture) Sex	Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Status 6/30/89
13	Hawk Inlet	M	18	270	6/11/86	S	Hunter kill 5/88
55	Greens Creek	F	7	124	6/21/83	H	--
55	Greens Creek	F	10	155[d]	7/10/86	H	--
55	Greens Creek	F	11	113	6/26/87	H	Transmiting
35	Wheeler Creek	F	8	135[d]	6/17/83	H	Mortality
18	Greens Creek	M	6	214[d]	6/17/83	H	Last located 8/85
16	Greens Creek	F	4	90[d]	6/16/83	H	--
16	Wheeler Mountain	F	8	170[d]	6/28/87	H	Transmitting
66	Greens Creek	M	4	180[d]	6/22/83	H	Last located 8/85
64	Eagle Peak	F	14	190[d]	6/24/83	H	--
57	Greens Creek	F	11	203[d]	9/28/83	H	Last located 7/85
68	Greens Creek	F	5	146[d]	9/28/83	H	Hunter kill 9/88
4	Greens Creek	F	6	214[d]	9/29/83	H	Hunter kill 9/87
19	King Salmon	F	13	191	9/29/83	H	Mortality
41	Mansfield Peninsula	M	2	135	6/21/84	H	Hunter kill 9/86
49	Mansfield Peninsula	M	3	100	6/16/84	H	No radio
81	Mansfield Peninsula	F	14	200	6/21/84	H	Last located 9/85
29	Wheeler Mountain	F	12	158	7/5/84	H	Last located 11/84
69[g]	Eagle Peak	M	2	59	7/9/85	H	Radio lost 5/86
79	Hawk Inlet	F	5	124	6/11/86	S	Hunter kill 9/87
27[h]	Greens Creek	M	2	77	6/11/86	S	--
27[h]	Greens Creek	M	3	154[d]	6/28/87	H	--
27[h]	Lake Florence	M	5	159	7/6/88	H	Removed radio
28	Greens Creek	M	13	260	6/11/86	S	--
28	Wheeler Mountain	M	13	260	7/10/86	H	Hunter kill 5/87
61	Hawk Inlet	M	10	215	6/12/86	S	--
61	Hawk Inlet	M	12	215	6/27/88	H	Hunter kill 5/89
77	Greens Creek	M	3	115	6/26/86	H	Hunter kill 5/89
46	Greens Creek	M	11	248[d]	6/2/86	H	Transmitting

Table 2. Continued.

Bear No.	Location	Capture (recapture) Sex	Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Status 6/30/89
52	Greens Creek	M	5	190	6/26/86	H	Transmitting
98	Greens Creek	M	19	315[d]	6/26/86	H	Transmitting
96	Mansfield Peninsula	F	7	148	6/3/86	H	Last located 10/87
89	Eagle Peak	F	15	150[d]	7/9/86	H	DLP 8/87[i]
84	Wheeler Mountain	F	11	213[d]	7/9/86	H	Transmitting
97	Greens Creek	M	11	293[d]	7/10/86	H	Transmitting
76[j]	Greens Creek	M	2	130[d]	7/10/86	H	--
76[j]	Lake Florence	M	3	168	7/6/88	H	Transmitting
78	Greens Creek	F	(3)	91	7/10/86	H	Mortality 8/86
85	Wheeler Mountain	F	11	150	7/11/86	H	Transmitting
25[k]	Greens Creek	M	2	68	6/26/87	H	Transmitting
71	Wheeler Mountain	F	3	148	6/29/87	H	Lost radio 8/87
54[l]	Eagle Peak	M	3	73	6/26/87	H	Lost radio 1988
70[m]	Greens Creek	F	4	118	9/16/88	H	Transmitting

[a] Age determined by tooth sectioning or (estimated).
[b] Weight estimated.
[c] S = snare; H = helicopter; D = darted, free ranging; T = trap.
[d] Actual weight.
[e] Offspring of No. 60.
[f] Offspring of No. 7; Pack Creek problem bear called "Pest."
[g] Offspring of No. 99.
[h] Sibling of No. 76, probably offspring of No. 56.
[i] DLP = defense of life property.
[j] Sibling of No. 27, probably offspring of No. 56.
[k] Offspring of No. 55.
[l] Offspring of No. 64.
[m] Offspring of No. 60.

Table 3. Summary and status of brown bears captured on Chichagof Island, summer 1983 through 30 June 1988.

Bear No.	Location	Sex	Capture (recapture) Age[a]	Weight (kg)[b]	Date	Capture techniques[c]	Status 6/30/88
23	Kadashan	M	5	158[d]	6/23/83	H	Last located 1983
21	Corner Bay	F	Adult	168[d]	6/23/83	H	Radio lost 6/85
88	Kadashan	M	5	167[d](190)	6/23/83(7/18/85)	H	DLP[e] 5/86
24	Corner Bay	F	16	225[d]	6/23/83	H	Radio lost 9/84
12	Kook Lake	F	3	100	6/24/83	H	Radio lost 8/84
30	Kadashan	M	3	126[d](136)	6/24/83(9/16/83)	H/S	DLP 11/86
2	Crab Bay	M	6	216[d]	6/24/83	H	Last located 1984
73	Kadashan	F	11	158(181)[d]	8/8/83(7/12/84)	S	Last located 1987
18	Kadashan	M	19	215	9/16/83	S	Hunter kill 5/84
44	Kadashan	F	Adult	272	9/17/83	S	Found dead 9/84
90	Corner Bay	M	4	135	9/22/83	D	Last located 5/84
32	Kadashan	F	5	136	7/10/84	S	Last located 1988
11[f]	Kadashan	F	2(3)	118(100)[d]	7/10/84(6/20/85)	S/H	Last located 1987
82	Kadashan	F	4	145[d](158)[d]	7/11/84(7/15/85)	S	Last located 1988
53	Kadashan	F	16	215	7/12/84	S	Last located 1987
65[g]	Corner Bay	F	3	79	7/19/84	S	Unreported kill
33[g]	Corner Bay	F	3	79	7/19/84	S	Last located 1985
26	Kadashan	F	18	200[d](180)	7/21/84(8/1/85)	S	Radio lost 5/86
9	Kadashan	F	Adult	154[d]	7/21/84	S	Last located 1985
3	Kook Lake	M	3	136[d](167)[d]	10/2/84(7/18/85)	S	Last located 1986
22	Kook Lake	F	3	91	10/8/84	S	Last located 1987
17	Crab Bay	M	4	200[d]	6/18/85	H	Last located 1987
5	Crab Bay	F	4	118[d]	6/18/85	H	Last located 1987
70	Kadashan	M	4	163[d]	6/18/85	H	Last located 1986
15	Corner Bay	F	5	113[d]	6/18/85	H	Last located 1987
25	Crab Bay	F	15	159[d]	6/20/85	H	Last located 1986
7	Kadashan	F	17	160	7/19/85	S	Last located 1987

Table 3. Continued.

[a] Age determined by tooth sectioning or (estimated).
[b] Weight estimated.
[c] H = helicopter; S = snare; D = darted, free ranging.
[d] Actual weight.
[e] DLP = defense of life or property.
[f] Offspring of No. 73.
[g] Probably offspring of No. 24; No. 33 and No. 65 are siblings. We received an unconfirmed report that one of these bears was killed at Corner Bay and the collar destroyed.

Table 4. Summary of alpine bear surveys conducted on northern Admiralty Island from 1983 through 1988.

	1983	1984[a]	1985	1986[b]	1987[c]	1988
Survey time (hrs)	1.8	1.0	1.5	2.1	2.2	1.5
Bears observed:						
adults	28.0	18.0	30.0	24.5 (1.3)	33.8 (5.3)	28.0
cubs of year	7.0	2.5	5.0	8.0	5.6 (1.1)	8.0
total cubs	14.0	10.5	6.0	14.0 (1.9)	18.8 (3.0)	19.0
cubs:100 adults	50.0	58.3	20.0	57.7 (8.6)	56.2 (4.2)	67.8
Total	42.0	28.5	36.0	38.5 (2.1)	52.6 (8.1)	47.0
Bears/hour	23.3	28.6	24.0	18.3	25.0 (4.6)	31.3
Area (km^2)	390	390	390	344	344	344

[a] Mean of 2 surveys.
[b] Mean (SE) of 4 surveys.
[c] Mean (SE) of 5 surveys.

Table 5. Summary of alpine bear surveys conducted on Admiralty Island south of the study area, 1987 and 1988.

	1987[a]	1988
Survey time (hrs)	1.9	2.0
Bears observed:		
adults	34.7 (2.3)	39
cubs of year	4.3 (1.5)	8
total cubs	11.0 (1.5)	14
cubs:100 adults	31.6 (3.2)	35.8
Total	45.7 (3.5)	53
Bears/hour	24.4 (2.8)	26.5
Area (km^2)	400	400

[a] Mean (SE) of 3 surveys.

Table 6. Reproductive history of radio-collared female brown bears on Admiralty Island, 1981-89.

Bear No.	Age at capture (yrs)	Offspring[a] by year								
		1981	1982	1983	1984	1985	1986	1987	1988	1989
60	20	1 2-yr	1 3-yr[b]	2 coy[c]	1 coy	1 1-yr	1 2-yr	1 3-yr	1 4-yr[b]	0
36	14	2 coy	--	--	--	--	--	--	--	--
14	7	0	0	0	2 coy	0[d]	0	2 coy	2 1-yr[e]	--
43	15	0	2 coy	2 1-yr	--	--	--	2 coy	2 1-yr	2 2-yr
6	8	0	0	1 coy[f]	0	0	--	--	--	--
62	14	--	0	0	0	0	0	--	--	--
38	23	--	0	0	0	0	0	--	--	--
99	17	--	2 3-yr[b]	2 coy	2 1-yr	1 2-yr[f]	--	--	--	--
63	17	--	2 cubs	0	0	2 coy	--	--	--	--
95	8	--	2 1-yr	2 2-yr[b]	0	2 coy	2 1-yr	--	2 coy	2 1-yr
34	2	--	0	0	--	--	--	--	--	--
56	13	--	2 2-yr	2 3-yr[b]	2 coy	2 1-yr	2 2-yr[b]	1 coy	0[f]	0[g]
67	2	--	0	--	--	--	--	--	--	--
37	10	--	0	1 coy	--	--	--	--	--	--
39	9	--	0	0	2 coy	0[f]	1 coy	?	1 coy	1 1-yr
7	11	--	1 coy	1 1-yr	1 2-yr	--	--	--	--	--
8	10	--	0	0	2 coy	2 1-yr	2 2-yr	2 3-yr[b]	1 coy	?
9	1	--	0	0	0	0	0	0[h]	0	0
35	8	--	0	--	--	--	--	--	--	--
16	4	--	0	0	--	--	0	0	0	0
91	19	--	0	--	--	--	--	--	--	--
92	16	--	0	2 coy	--	--	--	--	--	--
55	7	--	0	--	--	--	1 1-yr	1 2-yr	1 3-yr[b]	--
64	14	--	--	1 1-yr	1 2-yr[b]	2 coy	2 1-yr	2 2-yr	1 3-yr[b]	0
94	10	--	--	0	2 coy	2 1-yr	2 2-yr[b]	2 coy	2 1-yr	?
57	11	--	--	2 2-yr	2 3-yr	2 coy	--	--	--	--
68	5	--	--	0	0	0	0	?	0	--
4	6	--	--	0	2 coy	2 1-yr	--	--	--	--

Table 6. Continued.

Bear No.	Age at capture (yrs)	Offspring[a] by year								
		1981	1982	1983	1984	1985	1986	1987	1988	1989
19	13	--	--	1 2-yr	--	--	--	--	--	--
81	14	--	--	--	0	0	--	--	--	--
29	12	--	--	--	3 1-yr[i]	--	--	--	--	--
79	4	--	--	--	--	--	0	0[h]	--[j]	--
84	10	--	--	--	--	--	2 coy	2 1-yr	2 2-yr	2 3-yr[b]
85	7	--	--	--	--	--	1 coy	1 1-yr	1 2-yr[e]	--
89	10	--	--	--	--	--	2 coy	2 1-yr[k]	--	--
96	7	--	--	--	--	--	3 coy[f]	2 1-yr	--	--
78	3	--	--	--	--	--	--	0	--	--
71	6	--	--	--	--	--	--	0	--	--
70[l]	3	--	--	--	--	--	--	0	0	0

[a] coy = cub of year
1-yr = yearling
2-yr = 2-year-old
cub = cub older than coy
0 = no cubs observed.
[b] Cubs left over summer.
[c] Male killed cubs in June.
[d] Female ate cubs in den.
[e] Female killed by male, fate of cubs unknown.
[f] Cubs disappeared over winter.
[g] Female lactating but no cubs present.
[h] Observed breeding.
[i] One cub disappeared over summer.
[j] Killed by hunter 9/87.
[k] Female killed defense of life or property 8/87.
[l] Offspring of No. 60.

Table 7. Reproductive history of radio-collared female brown bears on Chichagof Island, 1983-88.

Bear No.	Age at capture (yrs)	Offspring[a] by year					
		1983	1984	1985	1986	1987	1988
21	Adult	0	3 coy	3 1-yr	--	--	--
24	16	0	2 coy	2 1-yr	--	--	--
12	3	0	0	0	--	--	--
73	11	2 1-yr	2 2-yr	1 3-yr[b]	3 coy	3 1-yr	--
44	Adult	0	3 coy[c]	--	--	--	--
32	5	0	0	0	--	--	1 1-yr
11[d]	2	0	0	0	0[e]	--	0
82	4	0	0	0	0	0[e]	0
53	16	--	0	2 coy	2 1-yr	--	--
65[f]	2	--	0	0	--	--	--
33[f]	2	--	0	0	0	--	--
26	18	--	2 cubs[g]	1 2-yr	--	--	--
9	5	--	0	0	--	--	--
22	3	--	0	0	0	--	--
5	4	--	--	0	0	--	--
15	4	--	--	0	0	--	--
25	11	--	--	2 1-yr	2 2-yr	--	--
7	17	--	--	2 1-yr	2 2-yr	--	--

[a] coy = cub of year
1-yr = yearling
2-yr = 2-year-old
cub = cub older than coy
0 = no cubs observed.
[b] Cub weaned in spring.
[c] Female found dead by midsummer.
[d] Offspring of No. 73.
[e] Observed breeding.
[f] Probable offspring of No. 24.
[g] Cubs different sizes.

Table 8. Percent seasonal distribution of radio-collared brown bears on Admiralty and Chichagof Islands, Alaska, 1981-88.

Habitat attribute	Percent of bear relocations							
	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
Elevation (m)								
n[c]	178	46	938	214	1,472	404	432	190
<300	43.3	54.3	31.0	61.7	75.7	88.6	24.8	69.0
300-600	28.1	37.0	22.5	29.0	10.5	7.7	29.4	25.8
600-900	23.0	6.5	32.1	8.4	10.7	3.2	34.9	4.7
>900	5.6	2.2	14.4	0.9	3.1	0.5	10.9	0.5
Slope (degrees)								
n[c]	178	46	938	214	1,472	404	432	190
<11	44.4	28.3	33.4	50.5	75.6	81.2	29.6	54.7
11-25	29.8	28.2	39.4	27.1	16.0	8.9	34.7	23.7
26-45	24.1	43.5	26.8	21.5	8.4	9.7	34.3	20.0
>45	1.7	0	0.4	0.9	0	0.2	1.4	1.6
Aspect								
n[c]	148	39	829	177	1,183	362	359	168
E/W	25.7	15.4	24.8	17.5	19.3	9.7	22.8	15.5
N	43.2	38.5	37.6	54.2	55.1	73.2	52.1	61.9
S	31.1	46.1	37.6	28.3	25.6	17.1	25.1	22.6
Terrain								
n[c]	176	46	926	214	1,467	403	432	183
Smooth	71.0	78.3	75.7	80.8	92.8	95.5	68.5	83.1
broken	29.0	21.7	24.3	19.2	7.2	4.5	31.5	16.9
Forest canopy %								
n[c]	178	46	938	214	1,472	404	432	190
<26	31.5	34.8	58.4	51.4	31.7	33.9	53.0	39.5
26-50	18.5	13.0	13.4	12.1	12.1	15.6	14.1	13.7
51-75	50.0	52.2	27.6	36.0	55.1	50.0	32.4	46.3
>75	0	0	0.6	0.5	1.1	0.5	0.5	0.5
Drainage								
n[c]	127	32	461	109	1,104	280	234	124
Poor	18.1	15.6	23.4	33.9	16.2	21.4	15.4	17.7
Good	81.9	84.4	76.6	66.1	83.8	78.6	84.6	82.3

Table 8. Continued.

Habitat attribute	Percent of bear relocations							
	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
<u>Habitat type</u>								
n[c]	178	46	938	214	1,472	404	432	190
Upland old-growth forest	59.5	63.0	31.1	40.7	31.9	20.0	29.4	42.6
Riparian old-growth forest	6.2	2.2	6.2	6.5	39.9	54.7	11.8	23.2
Subalpine forest	4.5	2.2	14.7	5.1	6.8	3.0	10.4	1.1
Alpine tundra	7.3	0	24.6	2.3	5.8	1.2	10.7	0.5
Alpine rock	5.6	0	3.7	1.4	0.1	0	12.0	2.1
Avalanche slope	13.5	26.1	14.7	22.9	9.9	9.2	25.2	19.0
Esturine grassflats	3.4	2.2	3.8	16.4	4.7	5.5	0.5	4.7
Clearcut	--	2.2	--	2.8	--	3.2	--	2.1
Other	0	2.1	1.2	1.9	0.9	3.2	0	4.7
<u>Riparian zone</u>								
n[c]	79	18	555	141	882	200	223	108
Within 160m	3.8	5.6	8.1	14.2	57.0	60.5	19.4	27.8
Beyond 160m	96.2	94.4	91.9	85.8	43.0	39.5	80.6	72.2
<u>Spruce composition (%)</u>								
n[c]	123	33	370	101	1,001	270	191	122
1-10	24.4	15.2	24.3	18.8	12.3	6.7	21.5	13.1
11-25	41.5	51.5	41.9	50.5	23.1	19.6	33.5	27.9
26-50	30.1	30.3	21.6	22.7	26.2	30.0	29.3	38.5
51-75	3.2	3.0	8.7	4.0	26.7	22.6	8.9	12.3
>75	0.8	0	3.5	4.0	11.7	21.1	6.8	8.2
<u>Timber volume (mbf/acre)</u>								
n[c]	125	33	391	103	1,019	270	194	122
<8	15.2	15.1	22.3	24.3	11.2	9.3	22.7	15.6
8-20	28.0	24.2	25.8	24.3	14.9	21.1	25.3	22.1
20-30	39.2	45.5	33.5	37.8	37.4	37.0	34.0	41.8
>30	17.6	15.2	18.4	13.6	36.5	32.6	18.0	20.5

Table 8. Continued.

Habitat attribute	Percent of bear relocations							
	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
Distance to alpine (km)								
n[c]	82	18	583	160	948	215	248	112
<0.9	36.6	27.8	58.3	25.0	17.8	13.0	66.9	22.3
0.9-1.6	23.2	22.2	9.3	19.4	3.4	13.5	8.1	10.7
1.7-4.8	32.9	27.8	23.3	40.6	68.1	49.8	21.0	48.2
>4.8	7.3	22.2	9.1	15.0	10.7	23.7	4.0	18.8
Distance to coast (km)								
n[c]	82	18	583	160	948	215	248	112
>0.2	14.6	5.5	12.7	26.3	14.9	19.1	12.5	9.8
0.2-0.8	15.9	16.7	11.7	12.5	31.5	22.3	9.3	27.7
0.9-1.6	8.6	16.7	6.3	5.6	19.3	15.8	7.7	11.6
1.7-4.8	25.6	33.3	16.8	33.1	16.9	31.6	18.1	33.0
4.9-8.0	26.8	27.8	27.8	27.1	21.9	9.0	11.2	16.1
>8.0	8.5	0	25.4	0.6	8.4	0	23.4	1.8
Distance to stream (km)								
n[c]	79	16	574	155	937	210	246	109
<161	7.6	6.3	12.7	25.2	60.7	64.8	24.8	31.2
161-483	10.1	0	5.6	17.4	13.0	11.4	2.0	9.2
484-805	16.5	25.0	6.4	8.4	4.1	5.2	2.9	13.7
>805	65.8	68.7	75.3	49.0	22.2	18.6	70.3	45.9
Distance to cover (km)								
n[c]	58	16	520	147	894	214	178	74
0	75.9	100	59.2	64.6	73.2	80.4	78.7	82.4
10-20	8.6	0	10.8	18.4	9.3	11.2	4.5	8.1
21-100	6.9	0	21.5	12.9	8.2	6.1	8.4	8.1
101-300	3.4	0	7.7	3.4	3.7	1.4	7.3	1.4
>300	5.2	0	0.8	0.7	5.6	0.9	1.1	--
Distance to roads (km)								
n[c]	54	15	420	141	854	205	174	74
<0.4	1.8	6.7	6.4	5.0	5.1	5.9	1.1	4.0
0.4-0.8	0	0	8.1	5.0	18.9	5.9	6.9	2.7
0.9-3.2	16.7	13.3	28.6	29.0	38.9	14.1	19.0	23.0
>3.2	81.5	80.0	56.9	61.0	37.1	74.1	73.0	70.3

Table 8. Continued.

Habitat attribute	Percent of bear relocations							
	Spring		Early summer		Late summer		Fall	
	A[a]	C[b]	A	C	A	C	A	C
Distance to clearcuts (km)								
n[c]	--	15	--	138	--	205	--	73
<0.4	--	13.3	--	11.6	--	12.2	--	16.4
0.4-0.8	--	0	--	11.6	--	7.8	--	6.9
0.8-1.8	--	0	--	29.7	--	1.3.2	--	9.6
>1.8	--	86.7	--	47.1	--	66.8	--	67.1

[a] Admiralty site.
[b] Chichagof site.
[c] Number of relocations.

Table 9. Seasonal habitat use of coastal brown bears[a] on Admiralty Island, Alaska, 1981-88.

Habitat type	Habitat use (%)				
		Summer			
	Spring	Early	Late	Fall	Annual
Old-growth forest					
Upland forest	55.9	28.2	24.5	30.6	28.4
Riparian forest	8.7	11.0	53.6	18.8	33.3
Beach fringe	6.8	4.9	2.0	1.5	3.1
Subalpine forest	3.7	14.0	5.2	10.3	8.4
Nonforest					
Avalanche slopes	12.4	15.7	5.5	23.2	11.3
Alpine	3.7	18.9	2.8	7.6	8.4
Estuary	3.8	4.5	5.3	0.6	4.3
Other	5.0	2.8	1.1	7.4	2.8
_n_ relocations =	161	772	1,285	340	2,558

[a] Interior bears are not included.

Table 10. Mean annual home range size for radio-collared brown bears on Admiralty and Chichagof Islands, Alaska, 1982-88.

	Home range size (km^2)				
Study area	$\bar{x}$	SE	Min	Max	n
Admiralty					
Male	99.7	10.71	10	285	46
Female	37.3	4.66	1	313	81
Chichagof					
Male	84.6	28.83	13	308	11
Female	24.9	4.45	4	85	28

Table 11. Use of clearcuts by instrumented brown bears relative to the availability of clearcuts within their seasonal home ranges.

		Home range (ha) by season[a]		Clearcut use[b] (%) by season		Availability (%) of clearcuts within seasonal home range by season	
Bear No.	Sex	1	2	1	2	1	2
2	M	3,858	--	0-	--	10.0	--
3	M	4,253	6,168	0-	0-	4.1	5.3
5	F	--	2,881	--	0-	--	2.4
7	F	9,643	9,527	0-	0-	2.5	2.5
11	F	--	1,294	--	0-	--	1.8
15	F	665	1,312	8+	4.2-	0.4	17.3
21	F	316	654	6.3+	9.1-	2.4	28.4
22	F	1,539	5,341	5.6[c]	3.7-	5.2	5.2
24	F	206	486	0-	9.1-	2.9	24.8
25	F	1,166	1,085	0-	0-	5.2	7.7
32	F	6,096	--	0-	--	4.3	--
53	F	3,943	127	0-	2.8-	7.5	7.4
70	M	1,038	1,652	0-	0-	4.9	1.5
73	F	924	1,541	0-	0-	5.0	1.6
82	F	4,258	7,861	6.7+	0-	4.4	4.5
88	M	--	1,607	--	21.2+	--	13.0

[a] Season 1 = den emergence through 15 July.
Season 2 = 16 July through den entrance.

[b] + = use greater than availability.
- = use less than availability.

[c] Difference between % use and % availability less than 1.

Table 12. Observations[a] of brown bears in the Corner Bay watershed, Chichagof Island, over 24-hour periods from 1645 hours on June 6 to 1100 hours on 13 June and from 1400 hours on 15 July to 1200 hours on 18 July 1986.

Date	Time	Habitat	No. bears	Marked bear
6/10	1645	Clearcut	1F/3 cubs	--
6/11	0930	Avalanche slope	1F/2 cubs	#53
6/11	1445	Clearcut	1F/3 cubs	--
6/11	2150	Avalanche slope	1F/2 cubs	#53
6/12	1355	Avalanche slope	1F	#15
6/12	2200	Avalanche slope	1F	#15
7/16	1603	Alpine meadow	1F	#15
7/16	1702	Alpine meadow	1F	#15
7/16	1838	Alpine meadow	1F	#15
7/16	1908	Alpine meadow	1F	#15
7/16	2005	Avalanche slope	1F/2 cubs	#53
7/17	1648	Alpine meadow	1F/2 cubs	--
7/17	2041	Alpine meadow	1F/2 cubs	#53
7/18	0608	Clearcut	1F/2 cubs	#53
7/18	0745	Clearcut	1F/2 cubs	#53

[a] Total observation time was 131 hours (excluding a gap of 5 hours from 2300 (6/12) to 0400 (6/13).

Table 13. Causes of mortality of radio-collared brown bears on Admiralty and Chichagof Islands, Alaska, 1981-89.

Sex	Age	Year	Location	Cause of death
F	2	1981	Admiralty	Capture-related
M	5	1983	Admiralty	Capture-related
M	6	1983	Admiralty	Capture-related
F	8	1983	Admiralty	Killed by male bear[a]
F	13	1983	Admiralty	Capture-related
F	3	1983	Admiralty	Hunter kill
M	5	1983	Admiralty	Hunter kill
F	11	1983	Admiralty	Hunter kill[b]
M	4	1986	Admiralty	Hunter kill
F	3	1986	Admiralty	Unknown
F	27	1986	Admiralty	Unknown[c]
F	6	1987	Admiralty	Hunter kill
F	10	1987	Admiralty	Hunter kill
M	14	1987	Admiralty	Hunter kill
F	16	1987	Admiralty	DLP[d]
M	5	1988	Admiralty	Hunter kill
M	20	1988	Admiralty	Hunter kill
M	?	1988	Admiralty	Hunter kill[e]
F	14	1988	Admiralty	Killed by male bear
F	10	1988	Admiralty	Hunter kill
M	?	1989	Admiralty	Hunter kill[e]
M	13	1989	Admiralty	Hunter kill
F	10+	1984	Chichagof	Unknown
M	20	1984	Chichagof	Hunter kill
F	4	1985	Chichagof	Unreported kill[f]
M	8	1986	Chichagof	DLP[g]
M	6	1986	Chichagof	DLP

[a] During recovery from capture immobilization.
[b] During deer hunting.
[c] Old bear probably died from natural causes.
[d] During deer hunting.
[e] Marked bear identification unknown.
[f] Reported to be killed at logging camp dump, bear had been fed.
[g] Bear had been fed at logging camp.

Table 14. Relationships between winter snowfall and chronology of spring den emergence by brown bears on northern Admiralty Island, 1982-85.

Year	Variation from $\bar{x}$ emergence date in days	Variation from $\bar{x}$ annual snowfall in cm (8 yr mean)
1982	+ 15	+ 114
1983	- 2	- 76
1984	- 9	- 89
1985	+ 8	+ 241

Table 15. Summary of brown bear day bed survey along 1.6 km of lower Zinc Creek, Admiralty Island, before road development in 1985 and during road development in 1986.

	Number of estimated day beds (%)				
Year	E[a]		W[b]		Total
1985	42	(74)	15	(26)	57
1986	8	(47)	9	(53)	17

[a] East of creek adjacent to road.

[b] West of creek away from road.

APPENDIX A.

DENSITY OF BROWN BEARS ON ADMIRALTY ISLAND, ALASKA

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Throughout the world, bears are declining in numbers and range as habitat is reduced and human-bear interactions increase (Schoen 1990). Brown bears (Ursus arctos) are particularly vulnerable to human encroachment. The population of North American brown bears is currently estimated between 52,000 and 63,000, of which about 65% occur in Alaska (Peek et al. 1987). As human populations continue to increase and resource use intensifies, conservation of brown bears becomes more difficult and population enumeration more critical, even in Alaska.

Estimating the size and trend of wildlife populations is a fundamental element of good management. However, estimating bear populations is difficult, costly, and lacking in quantitative rigor (Harris 1986, Miller et al. 1987, Peek et al. 1987). Miller and Ballard (1982) used a mark-recapture technique to estimate bear densities in Alaska. Mark-recapture techniques, however, are subject to numerous errors, particularly those associated with edge effects and visibility bias. Radiotelemetry combined with the mark-recapture technique has provided a useful tool for eliminating edge effects and visibility bias (Seber 1986, Miller et al. 1987, Pollock and Kendall 1987, Eberhardt 1990).

In 1981, we began a long-term ecological study of brown bears on Admiralty Island. An important component of this study was to monitor the effects on brown bears of a major hard-rock mine being developed in the Greens Creek drainage of Admiralty Island. The objective of the study reported here was to provide a baseline population density from which to compare the brown bear population before and after mine development.

We estimated the number of brown bears on a 344 km^2 study area around Greens Creek and Hawk Inlet on northern Admiralty Island ($58^{o}N$ $135^{o}W$), located within the Tongass National Forest in southeastern Alaska, using a modified capture-recapture technique (Miller et al. 1987). The study area contained the home ranges of a number of radio-collared brown bears (Schoen and Beier 1990) indicating that it was large enough to provide reasonable density estimates.

This region is characterized by a maritime climate with an average annual precipitation of 254 cm and heavy winter snow accumulations. The topography of the area is rugged with mountains rising from sea level to over 1,400 m. The lowlands of Admiralty Island are dominated by a dense old-growth rain forest of Sitka spruce and western hemlock (Picea sitchensis-Tsuga heterophylla). Broken rock, alpine tundra, and subalpine forests occur above 600 m. Interspersed throughout the forest are poorly drained muskeg bogs, avalanche slopes, and rivers and streams which provide spawning habitat for several species of anadromous salmon. Sixty-eight brown bears were radio-collared from 1981 through 1987 on or near the study area as part of a long-term research program (Schoen and Beier 1990). Loss of radiocollars occurred for a variety of reasons over the study period.

During the first half of July in 1986 and 1987, aerial mark-recapture surveys were conducted primarily in alpine habitats and during evening hours. Our previous research identified this time of day and season as being optimal for spotting and surveying bears in the study area. In terms of the mark-recapture surveys, marked bears were defined as those with radiocollars (Miller et al. 1987). We do not believe capture work influenced sightability of bears. In 1986, only 2 bears were captured on the same day as a survey flight, and these were captured after completion of the survey. In 1987, only 7 bears were captured; the last occurred 5 days previous to commencement of our mark-recapture surveys.

The number of marked bears within the study area was determined by telemetry at or near the time of the mark-recapture surveys. This allowed us to assume population closure (Miller et al. 1987, Eberhardt 1990) and meet assumptions discussed in Pollock and Kendall (1987). Counts of brown bears were divided into 2 groups during the surveys; an all bears count and a count of bears >2 years old. This eliminated the problem of bias where animals occur in groups, such as females with cubs (Samuel and Pollock 1981). We assumed equal sightability of marked and unmarked animals.

Daily estimates of population size (N_i) were calculated separately using Chapman's (1951) modification of the Peterson estimate (Seber 1982). We used the mean Peterson estimation method along with the bias correction factor described by Eberhardt (1990) for calculating confidence intervals. The goodness-of-fit method using a z-test was used to test for differences in estimates between years (Seber 1982:121).

Nine replicate surveys were conducted over 2 years and each took from 1.5 to 2.5 hours to complete. Inclement weather and low ceilings prevented the completion of additional surveys when bears were in alpine habitat. Males represented approximately one-third of our adult sample of marked bears. Offspring (<3 years old) accompanying marked bears represented 32-48% of our total marked population (if we assume they were also marked). Sightability of marked adults averaged 29%, and the number of marked bears available for sighting increased in the second year of the survey as more bears were radio-collared.

Estimates of brown bear numbers did not differ between years for all bears or bears >2 years old (z-tests, $P > 0.6$ for both tests). The 95% confidence intervals about the point estimates were large due to the lack of many replicates (Table 1). We also analyzed the data using the bear-days method and accompanying binomial confidence intervals as described by Miller et al. (1987) and obtained nearly identical results.

Density estimates were derived directly from the number of bears, thus they were also similar between years (Table 1). The average density within the entire 344 km^2 study area was 40 bears/100 km^2 (1 bear/mi^2) or 28 adult bears (>2 years old)/100 km^2.

Compared with other regions, the observability of bears in southeastern Alaska is poor because of the dense conifer canopy. Exceptions are high-elevation alpine areas and tidal wetlands. During the early July census period, all radio-collared bears used alpine habitat extensively. Observability was excellent in these areas, and this is where we concentrated our search effort. Search time for the alpine region was approximately 3 min/km^2.

Confidence intervals around our population estimate narrowed with each additional replicate similar to the results of Miller et al. (1987) and Ballard et al. (1990). We were unable to conduct additional replicate surveys because of inclement weather typical of southeastern Alaska. Bartmann et al. (1987) recommend that, for small populations, >40% of the population should be marked to obtain the most reliable estimates and confidence intervals. Logistics and financial constraints prohibited us from reaching this goal. However, Eberhardt (1990) suggests the mean Peterson method in association with his bias correction factor may improve abundance estimates of small populations. Regardless, we suggest exercising caution when interpreting our confidence intervals (Miller et al. 1987).

The density estimate for all bears on the northern Admiralty Island study site is substantially higher than other brown bear populations reported in the literature except Kodiak Island, Alaska. For example, estimated brown bear densities ranged from 2.0 to 3.0/100 km^2 in the Yellowstone ecosystem (Blanchard and Knight 1980), northern Yukon (Nagy et al. 1983), and Alaska's western Brooks Range (Reynolds and Hechtel 1984); 4.7 to 10/100 km^2 in Glacier Park (Martinka 1974) and the North Forks of the Flathead, British Columbia (McLellan 1984); and 29.0 to 34.8/100 km^2 on Kodiak Island (Barnes et al. 1988).

It has long been recognized that Admiralty Island has an abundant brown bear population. Dufresne and Williams (1932) surveyed the major salmon streams on Admiralty and estimated an island population of 900 bears including 149 bears on the northern portion of the island within the general vicinity of our study site. This is comparable with our average estimate of 139 bears.

Extrapolating the point estimate (0.4 bears/km^2) of the average density for our study area to the entire 4,403 km^2 island results in an island population of 1,761 bears. Although there may be more productive sites, our study area probably represents higher than average habitat capability for the island as a whole. Thus we consider our extrapolation an overestimate of the total number of brown bears on Admiralty Island. Our best "guess" is that there may have been 1,200-1,800 bears inhabiting the island in 1987. Although we recognize no one will ever know the size of the entire island population, these data suggest that our northern Admiralty Island study site has one of the highest density brown bear populations ever reported.

This density estimate has provided us with a baseline density of bears on northern Admiralty Island inhabiting an area influenced by the Greens Creek Mine. We now have an opportunity to replicate the estimate in future years and measure what, if any, effect the mine development has had on the resident brown bear population. Ballard et al. (1990) have established a similar baseline for brown bears associated with the Red Dog Mine in northwestern Alaska. Annual alpine surveys on northern Admiralty within and beyond the mine's influence can provide population trend information useful as a control.

The brown bear is a species of international interest and significance and a management indicator species for the Tongass National Forest. In a larger sense, brown bears may be a flagship species for biological conservation of Alaska's rain forest ecosystem. Mark-recapture surveys in combination with radiotelemetry provide a repeatable and quantifiable technique for monitoring population densities of brown bears relative to expanding timber and mining operations throughout their range in southeastern Alaska.

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Appendix A, Table 1. Mark-recapture brown bear population estimates from a 344-km^2 study area on northern Admiralty Island, Alaska, 1986-87.

		Mark-recapture estimates									
		No. bears							Density		
Year/group	Replication	n_1[a]	m_2[b]	n_2[c]	Sight-ability	$\hat{N}_i$	SE[d]	95% CI	Bear/km^2	95% CI	% marked[e]
1986, all bears	1	25	7	36	0.28	119					21
	2	28	4	34	0.14	202					14
	3	28	10	43	0.36	115					24
	4	41	11	41	0.27	146					28
$\bar{x}$ for replicates					0.26	146	17.3	82-209	0.42	0.24-0.61	21
1986, bears >2 years	1	17	4	22	0.24	82					21
	2	19	2	24	0.11	166					11
	3	19	6	24	0.32	70					27
	4	26	6	28	0.23	111					23
$\bar{x}$ for replicates					0.22	107	18.4	40-175	0.31	0.12-0.51	19
1987, all bears	1	36	8	22	0.22	94					38
	2	37	14	56	0.38	143					26
	3	37	15	56	0.41	134					28
	4	39	20	65	0.51	125					31
	5	38	15	67	0.40	165					23
$\bar{x}$ for replicates					0.38	132	10.5	100-165	0.38	0.29-0.48	28
1987, bears >2 years	1	19	4	14	0.21	59					32
	2	20	7	33	0.35	88					22
	3	20	7	36	0.35	96					21
	4	22	10	44	0.46	93					23
	5	21	8	42	0.38	104					20
$\bar{x}$ for replicates					0.35	88	6.9	68-110	0.26	0.19-0.32	23

Appendix A, Table 1. Continued.

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[a] n_1 = number of marked bears in population.

[b] m_2 = number of marked bears observed.

[c] n_2 = total number of bears observed.

[d] Calculated using the mean Peterson method of Eberhardt (1990) and bias correction factor (equation 13).

[e] Percent of estimated population that was marked.

APPENDIX B.

HABITAT CAPABILITY MODEL FOR BROWN BEAR IN SOUTHEAST ALASKA

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ABSTRACT: Habitat capability models are required for each management indicator species (including brown bears) on the Tongass National Forest. Habitat use data from radio-collared brown bears on Admiralty and Chichagof Islands were used to develop this habitat capability model. Each of 20 habitats was assigned a habitat capability value based on bear habitat preference or best professional judgment. The effects of human activity and resource development on brown bears were estimated, based on best professional judgment, as reductions in habitat capability within zones of human influence.

INTRODUCTION

Once widely distributed across western North America, brown/grizzly bears (Ursus arctos horribilis)[1] currently range over a significantly reduced portion of the continent and in 1975 were declared threatened in the United States south of Canada (LeFranc et al. 1987). Loss of habitat to human encroachment and resource development is a serious problem for bear management in the contiguous 48 states and elsewhere (Zager and Jonkel 1983, Contreras and Evans 1986, Schoen 1990).

In North America today, the largest population of brown bears occurs in Alaska (Peek et al. 1987) where there are an estimated 30,000-40,000 bears (Alaska Department of Fish and Game 1978). Brown bears are indigenous to Southeast Alaska where they occur throughout the mainland coast and on the islands north of Frederick Sound. Admiralty, Baranof, and Chichagof Islands have some of the highest brown bear densities (e.g., 1 bear/mi^2 [2.6 km^2] on northern Admiralty Island) in the world (Schoen and Beier 1990).

The decline in the range and numbers of brown bears during the past century in the contiguous 48 states has heightened management concern for this species and prompted an increase in brown bear research, particularly habitat-related studies. Most research on bear forestry relationships has been conducted within the last decade (see review in Zager and Jonkel 1983, Contreras and Evans 1986, Weaver et al. 1986, LeFranc et al. 1987) and several investigations are currently underway in British Columbia and Alaska (e.g., Hamilton and Archibald 1986, McLellan 1986, Schoen and Beier 1988).

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[1] Although considered the same species, U. a. horribilis is referred to as brown bear in coastal Alaska and grizzly bear in Interior Alaska and the remainder of North America.

The brown bear has been recommended for use as a management indicator species (MIS) in the revision of the Tongass Land Management Plan (Sidle and Suring 1986). Habitat capability models are needed for each of the MIS selected for use in the plan revision. These models will also be useful for project level planning and are necessary for providing information to evaluate the biological effects of proposed land management activities on wildlife habitats and populations. This model evaluates quality of habitat for brown bears which is assumed to be related to long-term carrying capacity. Habitats are rated, using habitat preference data from Schoen and Beier (1990), on the basis of their value to bears during late summer when bears are most concentrated and vulnerable to human activities and land-use practices.

Cumulative effects analysis is a relatively new but important component of forest planning (Christensen 1986, Weaver et al. 1986) and provides an approach for predicting the long-term effects of land management activities on brown bear habitat and populations. This model provides wildlife-forest managers with a tool for assessing cumulative effects of habitat change and human activity on brown bears.

Brown bears are one of the special features of the Tongass National Forest. Game Management Unit 4, which includes Admiralty, Baranof, and Chichagof Islands, is one of the most important brown bear hunting regions in the state, ranking third behind the Alaska Peninsula and Kodiak Archipelago with an average annual hunter harvest of 83 bears since 1980 (Alaska Department of Fish and Game, unpubl. data). Tourism and outdoor recreation are growing industries in this area. Many visitors to Southeast Alaska are interested in an opportunity to observe the brown bear which is considered a symbol of the American wilderness. Although much of Southeast Alaska is still undeveloped, significant levels of logging and mining are scheduled to occur throughout the range of the brown bear. Managers must therefore carefully evaluate and display the effects of such activities on brown bears to ensure that effects are minimized and that productive populations are maintained throughout their range in Southeast Alaska.

HABITAT RELATIONSHIPS

Odum (1971:234) described habitat as the organism's "address" or the place it inhabits in fulfilling its life needs (e.g., food, cover, water). Harris and Kangas (1988) proposed that the definition of primary habitat explicitly extends beyond the individual to include an area of sufficient size or configuration to support a population over time.

The habitat relationships of brown/grizzly bears vary considerably across the diverse array of ecosystems they inhabit from the eastern Rockies, through coastal rain forests, and to the Arctic. The Alaska Department of Fish and Game began brown bear investigations in Southeast Alaska in 1981 with particular emphasis on habitat relationships and the influence of logging and mining activities on bear populations (see problem analysis and literature review in Schoen 1986). From 1981 through 1988, 68 brown bears were radio-collared on northern Admiralty Island and 3,020 relocations collected (Schoen and Beier 1990). Habitat use by radio-collared brown bears varied seasonally ($\underline{P} < 0.01$) (Table 1) and is considered a response to seasonal differences in food quality and availability.

Most brown bears emerge from high-elevation (>1,000 ft [305 m]) dens between April and May. After den emergence, many bears move to low-elevation old-growth forests, coastal sedge meadows, or south-facing avalanche slopes. Bears seek out the new growth of vegetation on these sites which are the first to green up in the spring. During early summer (mid-Jun through mid-Jul), most bears move to forested slopes and alpine/subalpine meadows where they forage on newly emergent vegetation.

Bears concentrate along low-elevation coastal salmon streams from mid-July through early September. During this late summer season, 54% of all bear relocation occurred in riparian forest habitat vegetated by a spruce-devil's club (Picea sitchensis-Oplopanax horridum) community (Schoen and Beier 1990). During this same period, 66% of all bear relocations occurred within a 0.1 mi (161 m) band on either side of anadromous fish streams (J. Schoen and L. Beier, unpubl. data). Though this zone included a variety of habitats, it was dominated by the riparian spruce-devil's club community. Bears used this habitat for fishing along river banks, for foraging on succulent vegetation and berries, and for security and thermal cover.

Although most bears (>85%) are associated with anadromous fish streams in late summer, some bears (primarily females) do not use coastal fish streams (Schoen et al. 1986). These bears (termed "interior" bears) remain in interior regions of the island thoughout the year, foraging primarily on vegetation and berries in subalpine and avalanche slope habitat. By mid-September, most bears move to upper elevation (>300 m) forests, avalanche slopes, and subalpine meadows where they feed on currant (Ribes spp.) and devil's club berries before denning.

Winter denning begins in October and November. Mean elevation and slope of 121 den sites of radio-collared bears from Admiralty and Chichagof Islands were 2,100 ft (640 m) and 35 degrees (Schoen et al. 1987b). Fifty-two percent of these dens occurred in old-growth forest habitat. Though cave denning was common on Admiralty Island, many dens were excavated under large-diameter old-growth trees or into the bases of large snags (Schoen et al. 1987b).

The seasonal food habits of Admiralty brown bears were described by McCarthy (1989). During spring, the diet of these bears is dominated by sedges (Carex spp.), other green vegetation, roots, and deer. Sedges and salmon (Oncorhynchus spp.) are the major foods consumed during summer, although skunk cabbage (Lysichitum americanum), devil's club berries, and other plants, berries, and roots are also used. During fall, salmon, devil's club berries, skunk cabbage, sedge, beach lovage roots (Lisgusticum spp.), and currants dominate the diet. The distribution of bears corresponded closely to the seasonal abundance and quality of the food items listed above. Because bears have relatively inefficient carnivore digestive systems (Bunnell and Hamilton 1983) and are active for only part of the year, they must exploit the most productive feeding sites available. This often brings bears into conflict with humans using those same high-quality lands (Schoen 1990).

In Southeast Alaska, old-growth forest is used extensively throughout the year by brown bears for foraging, cover, and denning. Clearcut logging elsewhere often results in the production of an abundance of forage plants utilized by bears during early stages of forest succession (Lindzey and Meslow 1977, Mealy et al. 1977, Zager et al. 1983). Theoretically, these sites should provide good or adequate habitat for a generalist species like the brown bear. However, on Chichagof Island, clearcuts were rarely used by bears; only 2% of 866 relocations of 27 radio-collared bears occurred in clearcuts (Schoen and Beier 1988). Although clearcuts only encompassed about 6% of the Chichagof study area, they made up a much larger proportion of low-elevation valleys adjacent to streams--the areas used most extensively by bears in late summer. Brown bears possibly made limited use of clearcuts there because other sites (e.g., alpine/subalpine habitat, wetlands, riparian old growth, avalanche slopes) provided more nutritious foraging and better cover habitat than clearcuts (Schoen and Beier 1990). For example, devil's club berries, currants, and salmonberries, which are foraged on most extensively by bears (McCarthy 1989), are more abundant in riparian and avalanche slope habitat than in clearcuts. Because younger second-growth conifer stands (25-150 years old) in Alaska produce minimal understory vegetation, second growth provides poor foraging habitat for herbivores and omnivores such as bears (Wallmo and Schoen 1980; Alaback 1982, 1984; Schoen and Beier 1990).

HABITAT MODEL

This model assumes that habitat quality is related to brown bear preference for different habitats (e.g., alpine, riparian old growth, clearcuts, second growth). The ecological basis for infering habitat quality from preference data is found in habitat selection theory (Rosenzweig 1981, Fagen 1988). As stated by Ruggiero et al. (1988), "Habitat preferences are based on evolved behavior and thus relate directly to the probability of persistence. Therefore, habitat preferences must be viewed as reliable information about the environments needed for population persistence, and should be considered a valid basis for management decisions." While recognizing potential problems associated with population dynamics and interpretation of habitat availability (Johnson 1980, Van Horne 1983, McLellan 1986), we have used habitat preference of radio-collared bears on Admiralty Island as our measure of habitat capability for brown bears in Southeast Alaska.

Indices of habitat preference were calculated using a transformation of Ivlev's (1961) electivity coefficient as follows: $E_t = r_i/(r_i + p_i)$, where E_t = the transformed coefficient of electivity or habitat preference index, r_i = the proportion of observed use of category i (relocations of radio-collared bears), and p_i = the proportion of category i in the study area (availability).

Nine major habitat categories were identified for use in this model: old-growth forest, beach-fringe old growth, subalpine forest, second-growth forest, clearcuts, avalanche slopes, alpine, estuary, and other. Some of these were further subdivided relative to upland or riparian status, level of fish production, or age (Table 2).

Availability of habitats within the 141 mi^2 (365 km^2) Admiralty study area was estimated by extrapolation from a habitat data base derived for a 116 mi^2 (300 km^2) subsection of this study area. The original availability data (collected for a deer study) were determined from a random sample of 2,495 points systematically overlaid on 1:12,000-scale aerial photographs. These were: old growth, 75.6%; subalpine, 8.1%; alpine, 9.6%; and other, 6.6% (J. Schoen and M. Kirchhoff, unpubl. data). In this study, we recognized a greater variety of habitat categories than in the original study. Old-growth forest was further subdivided into upland, beach fringe, and riparian, and the relative abundance of each habitat was estimated. We also estimated the relative abundance of avalanche slopes and estuaries.

To simplify our habitat capability model, we assumed the late summer season was the most critical or limiting period for brown bears in Southeast Alaska. We acknowledge that other seasons (e.g., spring when bears are feeding on new growth of sedges at tidewater) also have unique importance to bears and that critical seasons may vary regionally. However, the late summer season (mid-Jun through mid-Sep) is when the most abundant, high-quality food (e.g., spawning salmon) is available. Brown bears are most concentrated along low-elevation valley bottoms and coastal salmon streams at this time. These are also the areas of highest human use and most intense resource development activities (e.g., logging and road building) resulting in the greatest vulnerability of the bears and their habitat to management activities. Late summer habitat use by radio-collared bears, habitat availability, index of habitat preference, and a habitat capability index (scaled from 0 to 1) are presented in Table 3. Habitat use determinations excluded "interior" bears because these bears represent a relatively small proportion of the population (approximately 10%), may be somewhat unique to Admiralty Island, and are relatively isolated from most forest management activities.

Several additional habitats are listed for which we did not have preference data from Admiralty Island. Although these habitats did not occur on the Admiralty study site or were not delineated, they are important because they are the result of forest management activities (e.g., clearcuts and second-growth forest) or are used extensively by bears and subject to a disproportionate amount of logging (e.g., riparian old growth). We ranked riparian habitats into 2 categories (streams with and without anadromous fish) based on best professional judgment (Table 2).

Because clearcuts (0-24 years) and second-growth forests (25-150 years) were not available within the Admiralty study area, their suitability was also ranked based on professional judgment (Table 2). The avoidance of clearcuts by radio-collared bears on Chichagof Island (Schoen and Beier 1990) and the minimal forage production of second growth (Wallmo and Schoen 1980, Alaback 1982) justify their low rankings. We distinguished an older category of second growth (151-300 years), however, with values intermediate between young second growth and old growth because of increasing availability of forage plants. Clearcuts and second growth in riparian sites with salmon streams were given higher value than upland sites because of the availability of spawning salmon.

Though availability of suitable den sites is an important component of brown bear habitat, we assume it is not limiting in most circumstances and is unlikely to be substantially impacted by forest management. However, to minimize loss of denning habitat as a consequence of logging, Schoen et al. (1987b) recommended avoiding logging on mid-volume (20-30 mbf/acre), hemlock-spruce stands on slopes greater than 20 degrees at elevations above 980 ft (300 m) in or adjacent to areas of brown bear concentrations.

HABITAT CAPABILITY

This model is designed to operate on a single- or multiple-watershed scale (e.g., Alaska Department of Fish and Game minor harvest areas). Each of the 23 habitats is assigned a habitat capability value based on habitat preference or best professional judgment (Table 3). The density of brown bears in the Admiralty study site was estimated at 1 bear/mi^2 (1/2.6 km^2) (Schoen and Beier 1990). We corrected this density to exclude the "interior" segment (10%) of the population. This resulted in a population of 127 bears within the 141 mi^2 (365 km^2) study area. This overall density and the composition of habitats on the Admiralty study area were used to estimate bear density in each habitat (Table 3).

As the mix of habitats is changed by forest management activities, we can estimate changes in bear numbers by totaling the amount of each habitat category and multiplying by the bear density for that habitat. Following estimation of habitat capability, the model then incorporates effects of human-induced disturbance and/or mortality.

HUMAN-INDUCED DISTURBANCE AND MORTALITY

Large carnivores, like brown bears, which range over extensive areas (from 1,000 to 100,000 acres [400-40,000 ha]) should be considered creatures of landscapes rather than of specific habitat types per se (Harris and Kangas 1988, Schoen 1990). Aside from habitat impacts, resource development (e.g., logging, mining, hydroelectric devlopment, tourism) must also be evaluated in terms of human-bear interactions (Peek et al. 1987, Mattson 1990, McLellan 1990, Schoen 1990). Resource development in brown bear habitat (generally wild, undeveloped areas) significantly improves human access and consequently increases disturbance as well as direct human-induced mortality of bears (Pearson 1977, Craighead et al. 1982, Schoen 1990). In general, roads are detrimental to bears because they increase opportunities for human-bear interactions (Elgmork 1978, Zager 1980, Archibald et al. 1987, Rogers 1987, Rogers and Allen 1987, McLellan and Shackleton 1988, Wilcove 1988, Schoen 1990). Although it is possible to manage legal hunting of bears, it is difficult to control illegal kills, wounding loss, and defense of life or property kills (Schoen et al. 1987a). Once an area is roaded for one development activity, it often results in additional developments which increase human-bear interactions, and ultimately reduces the areas capability for supporting viable bear populations (McLellan 1990).

The dense rain forest of Southeast Alaska provides more security cover for bears than more open habitats in the Rocky Mountains or northern Alaska. Road building activities in the Greens Creek drainage of Admiralty Island displaced fewer bears than expected, presumably because of the security cover provided by the dense forest (Schoen and Beier 1988). In Southeast Alaska, bears may remain closer to development activities because of the dense forest cover. As those bears become habituated to humans and/or associate humans with food (e.g., garbage), human-bear interactions will increase and result in higher bear mortality. Human garbage has been implicated as one of the major contributors to bear attacks on humans and ultimately the reason that many garbage-habituated "problem" bears must be destroyed (Herrero 1985:52, Herrero and Fleck 1990).

The combination of increased road access and bears becoming habituated to garbage dumps (and people) is a major concern of bear managers in the coastal forests of British Columbia and Southeast Alaska (Archibald 1983, Archibald et al. 1987, Weaver et al. 1989, Schoen 1990). For example, the brown bear season on northeastern Chichagof Island was closed under an emergency order of the Alaska Department of Fish and Game on 30 September 1988 because of high bear mortality resulting from increased road access and the inadequate garbage disposal policies of several small communities and logging camps. K. Titus (unpubl. data) found a direct correlation ($\underline{r}$ = 0.93, $\underline{P}$ < 0.001) between autumn brown bear kill and cumulative miles of road construction on northeastern Chichagof Island during the period 1978 to 1989. The number of illegal bears taken there during that period is a significant unknown. Clearly, the impacts of human activity and development on bears need to be incorporated into any analysis of the effects of land management activities on brown bears (Schoen 1990).

We subdivided the effects of human activity and development into different levels of impact. These relationship were estimated, based on best professional judgment, as reductions in habitat capability (or potential carrying capacity) within zones of human influence/disturbance (Table 4). These should be considered as general reduction factors (e.g., high, 0-0.3; medium, 0.4-0.7; light, 0.8-1.0) rather than specific quantifiable values derived from research.

We estimated that larger communties would have greater impacts than smaller communities. For example, brown bears are rarely observed in or adjacent to major cities or towns in Southeast Alaska, whereas they are much more frequently encountered near small villages. This indicates that suitable habitat is not used adjacent to these areas because the bears are killed or displaced. Even though the habitat may be suitable, it is not used and its value to bears decreases. We similarly estimated that permanent camp sites would have more impacts than temporary camps. We also assumed that camp sites frequented by transient workers (many with limited experience in Alaska) would be less inclined to tolerate bears than long-term permanent residents.

Landfills without effective fuel-fired incineration and/or bear-proof fencing attract bears from long distances. These bears become habituated to humans and human foods and are more prone to interact with humans, thus decreasing their probability of long-term survival.

Road access was considered detrimental to bears. Arterial and collector roads accessible to vehicles were estimated to have greater impacts on bears than local roads and roads closed to vehicular traffic. We believe that roads closed administratively (e.g., with gates or excavated pits) would still have some level of off-road vehicle traffic. Although less detrimental to bears than roads accessible to vehicles, roads closed temporarily (e.g., with gates) pose greater impacts than permanently closed roads (e.g., through bridge removal). We believe that all roads, regardless of closure, still have the potential for supporting additional human foot traffic which also influences bear populations.

MODEL VERIFICATION

This model has received interagency review by biologists from the Alaska Department of Fish and Game and the USDA Forest Service. The next stage in verification will be implementation in a pilot test of the GIS data base currently being developed for Southeast Alaska by the USDA Forest Service. This will allow biologists to game with the model to determine whether test results appear reasonable. Once the GIS is operational, the actual proportion of habitat types within the 141 mi^2 northern Admiralty Island study area can also be determined. After completion of the GIS data base, we will contrast model results between our study sites on Admiralty and Chichagof Islands where we have estimates of relative bear densities. Following these exercises, the model will be submitted for review to additional bear experts who were not involved in model development.

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Table 1. Seasonal habitat use by radio-collared brown bears[a] on Admiralty Island, Southeast Alaska, 1982-88.[b]

Habitat type	Percentage of habitat use				
		Summer			
	Spring	Early	Late	Fall	Annual
Old-growth forest					
Upland forest	55.9	28.2	24.5	30.6	28.4
Riparian forest	8.7	11.0	53.6	18.8	33.3
Beach fringe	6.8	4.9	2.0	1.5	3.1
Subalpine forest	3.7	14.0	5.2	10.3	8.4
Nonforest					
Avalanche slopes	12.4	15.7	5.5	23.2	11.3
Alpine	3.7	18.9	2.8	7.6	8.4
Estuary	3.8	4.5	5.3	0.6	4.3
Other	5.0	2.8	1.1	7.4	2.8
n relocations =	161	772	1,285	340	2,558

[a] Interior bears were not included.

[b] Schoen and Beier (1990).

Table 2. Description of habitat categories used in the habitat capability model for coastal brown bears, Southeast Alaska.

Habitat	Description
Physiographic categories	
Beach fringe	Within 500 feet of mean high water
Estuary fringe	Within 1,000 feet of mean high water along an estuary
Riparian zone	Zone within 0.1 mile of a stream, influenced by riparian habitat
Upland	Area between the beach and estuary fringes and the subalpine, excluding the riparian habitat
Forest categories	
Old growth	Forest stands greater than 300 years old
Subalpine	Ecological subalpine zone
Clearcut	Stands 0-25 years old
Young second growth	Stands 26-150 years old
Older second growth	Stands 151-300 years old
Nonforest categories	
Avalanche slopes	Recurrent slide zone
Alpine	Ecological alpine community
Estuary	Portion of an estuary below mean high water
Other	Miscellaneous (e.g., muskeg, rock, roads)
Stream categories	
Fish	Anadromous fish present
No fish	No anadromous fish present

Table 3. Habitat capability for brown bear habitats during the late summer season in Southeast Alaska.

Habitat	Use[a] (%)	Availability[b] (%)	Preference[c] index	HCI[d]	Density[e]
Upland forest					
old growth	24.5	55	0.31	0.34	0.84
subalpine	5.2	10	0.34	0.37	0.91
old 2nd growth	--	--	--	0.10[f]	0.25
young 2nd growth	--	--	--	0.00[g]	0.00
clearcut	--	--	--	0.10[g]	0.25
Riparian forest					
old growth	53.6	5	0.91	1.00	2.47
fish	--	--	--	1.00[g]	2.47
no fish	--	--	--	0.40[g]	0.99
old 2nd growth					
fish	--	--	--	0.30[f]	0.74
no fish	--	--	--	0.10[f]	0.25
young 2nd growth					
fish	--	--	--	0.20[f]	0.49
no fish	--	--	--	0.00[f]	0.00
clearcut					
fish	--	--	--	0.50[f]	1.24
no fish	--	--	--	0.20[f]	0.49
Beach-fringe forest	2.0	3	0.40	0.44	1.09
Estuary-fringe forest	--	--	--	0.60[f]	1.48
Avalanche slope	5.5	5	0.52	0.57	1.41
Alpine	2.8	10	0.22	0.24	0.59
Estuary	5.3	2	0.73	0.79	1.95
Other	1.1	10	0.10	0.11	0.27

[a] Habitat use by radio-collared brown bears on Admiralty Island.

[b] Availability of habitats on Admiralty Island study site.

[c] Transformation of Ivlev's (1961) electivity coefficient (E_t).

[d] Habitat capability index = E_t scaled from 0-1.

[e] Bear density (per mi^2) by habitat from Admiralty study site.

[f] HCI determination based on best professional judgment.

[g] Extrapolated from Schoen and Beier (1988) and best professional judgment.

Table 4. Reductions in brown bear habitat capability within zones of human activity/disturbance in Southeast Alaska.

Human activity/ landscape modification	Habitat reduction factor within zone of influence[a]	
	<1 mi	1-5 mi
Human communities		
>1,000	0.0	0.3
501-1,000	0.0	0.5
11-500	0.3	0.6
<10	0.5	0.8
Landfill without effective incineration	0.0	0.5
Forest Service cabin/developed campground	0.8	1.0
Permanent camp site	0.2	0.5
Temporary camp site	0.5	0.8
Access point (airstrip, dock, float plane lake)	0.8	1.0
Arterial and collector roads accessible to vehicles and connected to ferry access or town	0.4	0.7
Local roads accessible to vehicles	0.6	0.9
Roads closed temporarily	0.8	1.0
Roads closed permanently	0.9	1.0

[a] Habitat capability multiplied by this factor equals bear potential within the specified zone. Derivation of reduction factors based on best professional judgment.

APPENDIX C. List of Publications

McCarthy, T., and J. W. Schoen. In review. Brown bear food habits on Admiralty Island, southeast Alaska. J. Wildl. Manage.

Peek, J. M., M. R. Pelton, H. D. Picton, J. W. Schoen, and P. Zager. 1987. Grizzly bear conservation and management: a review. Wildl. Soc. Bull. 15:160-169.

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Schoen, J. W., and K. Titus. In review. Brown bear density on Admiralty Island, Alaska. Wildl. Soc. Bull.

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