Christian P. Dau
Izembek National Wildlife Refuge
P.O. Box 127
Cold Bay, Alaska 99571

BROWN BEAR HABITAT AND MOVEMENTS ON THE LOWER ALASKA PENINSULA

ABSTRACT: From August 1984 to March 1988, 36 radio-collared brown bears (Ursus arctos) marked in 1984 and 1985 were tracked using aircraft to determine seasonal distribution and habitat use. This high density bear population is potentially vulnerable due to varied land ownership patterns, management strategies and increasing public use. Marked bears were located 433 times within a 2002 km^2 study area on and adjacent to the Izembek National Wildlife Refuge, Alaska. Habitat type was identified at 301 (69.3%) marked bear locations. From May through November, 67% of bear locations were in lowland habitats versus 20% in midland and 13% in upland habitats. Dense alders (Alnus spp.) provided day-bed and escape cover. During the non-denning period, food availability restricted most bears to lowlands and coastal beaches near anadromous fish streams. Elevation, aspect and bear density were determined at 48 dens of marked bears. Uplands usually above 300 m in elevation were preferred for denning. Home range of marked bears averaged 19 km^2 for males, 12 km^2 for non-maternal females and 9 km^2 for 17 maternal females. These small home ranges indicated that all necessary food and habitat requirements were present in a small geographic area.

Key Words: Brown bear, movements, home range, habitat use, Izembek National Wildlife Refuge, Alaska Peninsula

From August 1984 through March 1988, home range and habitat relationships of 36 radio-collared brown bears were investigated by aerial tracking on and adjacent to the Izembek National Wildlife Refuge, Alaska. Increasing public use (primarily hunting) various commercial uses, geological research and differing land management strategies are some potentially detrimental factors affecting this high density brown bear population or its habitat. This study was initiated to provide baseline information on home range size and habitat use. Previous brown bear investigations along the lower Alaska Peninsula addressed fall population size and composition (Izembek refuge, unpublished data) and seasonal distribution near an area of human habitation (Dau 1989).

The geographic requirements of this population were quantified to provide a basis for present and future land management decisions. The geographically restricted home range sizes of adults, with and without family groups, monitored during the study suggest that detrimental management strategies in restricted areas could impact the entire population. The extent of emigration of subadault bears from the study area to peripheral areas of lower density was not determined, however, this factor may be important in determining numbers in adjacent areas.

This study was performed by personnel of the Izembek National Wildlife Refuge. Former refuge managers J. Sarvis and M. Blenden assisted in the work and reviewed progress reports. I also thank R. Sellers and M. McNay, Alaska Department of Fish and Game, for assistance with 1984 captures and initial radio tracking. Refuge Managers M. Blenden, J. Sarvis, R. West and M. Chase reviewed the manuscript which was typed by D. Christensen.

STUDY AREA

This study was conducted in a remote 2002 km^2 area of the lower Alaska Peninsula (Fig. 1). Lowland habitats provide stream, spring and lake spawning habitat to all 5 species of Pacific salmon, support a minimum fall population of 220 brown bears (Izembek refuge, unpublished data). Lowland habitats are characterized by wet, herbaceous meadows with lakes and streams interspersed with areas of ericaceous shrub.

Low sand dunes vegetated with Lyme grass (Elymus spp.) or low bluffs less than 10 meters high, characterize beaches along Dau the northern, Bering Sea border of the study area. Beaches of rock and gravel characterize areas along Cold Bay and Pavlof Bay. Sand and mud flats predominate in the Moffet Bay area. Midland elevations are dominated by a narrow, dense tall shrub zone of alder (Alnus spp.).

Higher elevations in the study area are characterized by volcanic peaks and formations up to 2500 meters in elevation, and associated barren rock and volcanic ash fields. Limited areas of ericaceous shrub are also found in upland areas. The entire area is of volcanic origin with recent seismic and volcanic activity (Brophy 1984, Marlow and Cooper 1984).

The climate of the area is maritime with average annual monthly high and low temperatures of 5.8° C (range 0.1 to 13.0) and 0.7° C (range -5.2 to 8.3), respectively. Daily wind speeds average 27.0 km/h (range 25.1 to 28.6) and annual precipitation averages 88.9 centimeters. Overcast conditions (100% cloud cover) occur on an average of 303 days per year versus an average of 12 clear days (National Weather Service, Cold Bay, Alaska).

The majority of the study area is within 2 units of the Izembek refuge (Table 1). Capture activity was largely confined to low herbaceous meadows within the Left-hand and Right-hand Valley areas of the Izembek Unit of the refuge. The Izembek Unit is designated Wilderness while some Pavlof Unit lands, including those within the study area, are proposed for Wilderness designation (USFWS 1985).

Five basic habitat zones identified within the study area were predominated by unvegetated uplands and wet herbaceous meadows (Table 2).

METHODS

In 1984 (30 Jul. - 20 Aug.) and 1985 (16 Jul. - 9 Aug.), a total of 59 brown bears were captured using helicopters and immobilizing drugs administered with a dart gun. Bears of both sexes and maternal females within each family group age category, were captured. All bears captured were individually marked with numbered ear tags and lip tattoo and most adults were collared with radio transmitters (Telonics, Mesa, AZ.). Most bears were weighed and a premolar tooth was removed for aging bears of unknown age.

Radio collared bears were relocated using a Piper PA-18 aircraft with a scanner receiver and side-looking RA-2A or a forward-looking 3 element yagi antenna (Telonics, Mesa, AZ.). Relocations were attempted at bi-weekly intervals throughout the non-denning period. Two to 7 flights were made each winter to determine denning locations and characterize each site including elevation, aspect and slope. Radio locations or sightings of marked bears were plotted on 1:63,360 maps and 1:120,000 black

and white aerial photographs. During each relocation, presence and number of associated bears, including attendant cubs, was noted.

The study area was divided into 5 habitat zones identifiable on color infra-red (1:60,000) aerial photography (Table 2). Most bear relocations obtained during diurnal hours were assigned to more distinct habitat types in these zones (Table 2). Elevations at each relocation, including den sites, were estimated using the aircraft altimeter. The habitat zones were assigned to lowland, midland or upland elevational boundaries corresponding to the limits of the primary vegetation unit within each zone. Lowlands extended from sea level to the tall shrub zone, which characterized midland elevations. Uplands extended upward from the elevational limit of the tall shrub zone and were characterized by sparsely or un-vegetated habitats. A planimeter was used to determine the area within each habitat zone. Crepuscular and nocturnal habitat use and activity was evaluated for 1 12 hour period in fall by radio tracking from 2 ground stations. Minimum home range sizes were determined for each radio-collared bear tracked into the denning period using a planimeter to measure convex polygons encompassing all observations (Mohr 1947).

Home range sizes of males, non-maternal females and maternal females within each family group age category were summarized to determine average size and patterns of habitat use. Den site characteristics including elevation, aspect, steepness of slope and proximity to other collared bears were also summarized by sex and maternal status. An index of denning concentration, based on the number and proximity of collared bears, was used to identify areas of high, medium or low density and to assess preferences for such areas by both sexes and female maternal status. Areas with 3 or more other collared bears within a 1 km radius of a den site were termed high concentration. Medium and low concentration denning areas had fewer than 3 other collared bears and no other collared bears, respectively, within the area.

RESULTS AND DISCUSSION

Fifty-nine brown bears were captured, primarily within the high density area of Left-hand and Right-hand Valleys, in July and August of 1984 and 1985. Most bears were captured in lowlands below 150 m in elevation. Thirty-six of the 39 adults captured (30 females, 9 males) were collared with radio transmitters (Table 3).

Relocations of radio-collared bears were obtained during 44 tracking flights which resulted in 433 observations. Seventy-

eight percent of relocations were during the non-denning period. Unsuitable weather hampered aerial tracking efforts resulting in a 32 percent reduction in the planned survey effort. Radio tracking during 24 non-denning and 10 denning period flights resulted in 301 relocations identified to habitat type and characterization of specific den sites.

Relocations of 6 radio-collared bears, during mid-July to mid-August, provided the only assessment of daily movements during this study (Table 4). Ballard et al. (1982) reported average daily movements of 7.7 km/d for male and 7.0 km/d for female brown bears during late May and June at an interior Alaska site. Pearson (1975) found daily activities and movements of interior Canadian grizzlies associate with gathering of food throughout most of the year. Craighead (1972) stated that distribution and availability of food in addition to proximity of mates, habitat preference, foraging habits, age, sex and condition and other factors dictate home range size in grizzly bears. Erickson and Siniff (1963) suggested that daily movements of coastal brown bears along the central Alaska Peninsula were small and usually associated with specific drainages. In this study, brown bear movements were short from mid-July to mid-August due to the close proximity of foraging areas and cover.

Availability of spawning salmon, the primary food source, peaks during late July and August. Tall shrubs, used as day bed areas and escape cover, are adjacent to salmon spawning sites throughout the study area. Glenn and Miller (1980) found brown bear movements to be greater during spring (June) and fall (September and October) on their central Alaska Peninsula study area. They further suggested that upland habitats are used to a greater degree during those periods than during the summer (July and August). Data from this study agree with the trend in seasonal movements identified by Glenn and Miller (1980), however, overall movements and resulting home range size was 93% and 97% smaller in this study for males and females, respectively.

Fifteen radio-collared bears, tracked over 1 12 hour period (26 - 27 Sept. 1985) from ground stations overlooking Left-hand Valley, were active throughout the crepuscular and nocturnal periods. Included were 10 individual bears (2 males, 8 females) and 5 maternal females.

Pearson (1975) suggested that nocturnal activity patterns of grizzly bears were tied to food gathering and that the level of activity did not change with season. Studies by Pearson (1975) and Erickson and Siniff (1963) also suggested that bear activity peaks during crepuscular periods. In this evaluation, all

collared bears were active during both nocturnal and crepuscular periods, however, peaks of activity could not be quantified. Forty-one bears in view from the 2 stations at first light, suggest that morning crepuscular activity is high and rapidly decreases. Within 2 hours, of first light, all of these animals had moved into tall shrubs.

HABITAT USE

Seasonal habitat use was determined by identifying habitat types for 301 relocations (69.5%) of collared bears during the non-denning (n = 246) and denning (n = 55) periods (Fig. 2, Tables 5 and 6). All 433 relocations of radio-collared bears were partitioned, by seasonal period, to areas of different land ownership or designation (Fig. 3). During the non-denning period most relocations were in lowland (67.9%) versus midland (19.9%) and upland (12.2%) elevational zones (Table 5). During the non-denning period, collared bears were primarily distributed in lowland habitats where food availability was greatest and in lowland and midland areas of tall shrub which provided cover. Glenn and Miller (1980) reported habitat use by brown bears during spring and summer was greatest in lowland areas versus midland and upland areas in fall. The seasonal habitat use patterns identified in this study agree with those of Erickson and Siniff (1963) and Glenn and Miller (1980).

However, in this study, necessary habitat requirements were compressed into a smaller geographic area which resulted in shorter movements and small home ranges.

Denning normally occurred from mid-November through April. Very few bears on the lower Alaska Peninsula remain active into December or do not den at all. No bears radio tracked during this study failed to den. Forty-eight (91%) denning locations of marked bears were primarily in barren or glacier/icefield habitat zones at high elevation (Table 6). Precipitous slopes, of variable aspect, characterized by a mixed rock and soil substrate were preferred as denning locations (Table 7). No snow dens were known to be used by collared bears. Of 30 den sites examined by Lentfer et al. (1972) along the central Alaska Peninsula, 29 were constructed in soil and 1 in snow. Van Daele et al. (1990) reported 5 snow dens in 135 sites investigated on Kodiak Island. No significant differences found ($P > 0.05$) between den elevations of 9 males ($\bar{x}$ = 586m $\pm$ 280) and 39 females ($\bar{x}$ = 814m $\pm$ 231). However, den site elevations were significantly higher ($P < 0.05$) for 17 maternal females ($\bar{x}$ = 848m $\pm$ 262) than for males but not ($P > 0.05$) for 22 non-maternal females ($\bar{x}$ = 795m $\pm$ 177). Den elevations of 6 females 4-5 years old, ($\bar{x}$ = 941m $\pm$ 185) were not significantly greater ($P > 0.05$) from those of 29 females older than 6 years ($\bar{x}$ = 796m $\pm$ 229).

Lentfer et al. (1972) reported an average den elevation of 396 m for 49 bears in the central Alaska Peninsula where the topography seldom exceeded 900 m. Data from Lentfer et al. (1972) further suggested that maternal and non-maternal females showed similar patterns in their use of denning sites below 305 m, from 305 to 458 m and above 458 m. Van Daele et al. (1989) reported average den elevations of 665 m (range 91 to 1189) and 457m (range 128 to 915), respectively for bears at 2 Kodiak Island study sites but found no consistent trends annually or by sex. In southeast Alaska, Schoen et al. (1987) reported 640 m (range 6 to 1190) as the average elevation of 121 brown bear dens. As in this study, Schoen et al. (1987) found that females ($\bar{x}$ = 658m $\pm$ 23) denned at higher elevations than did males ($\bar{x}$ = 535 $\pm$ 47).

Radio-collared brown bears in this study preferred den sites on steep slopes. Slopes estimated greater than 45^{o} characterized 37(77%) of the den sites observed (Table 7). Four dens (8%) were on slopes of 30^{o} to 45^{o} and 7(15%) were on slopes of less than 30^{o}. On the central Alaska Peninsula Lentfer et al. (1972) found a preference for denning sites on slopes of 30^{o} to 45^{o} (50%) versus slopes of less than 30^{o} (32%) or over 45^{o} (18%). Differences in these 2 Alaska Peninsula areas probably relates to habitat availability. Steep slopes (> 45^{o}) were preferred by 52% of denning brown bears on Kodiak Island as compared to 40% use of moderate slopes (30-45^{o}) and 8% use of slopes less than 30^{o} (Van

Daele 1989). Schoen et al. (1987) reported an average slope of 35° (range 5° to 75°) for 121 dens in southeast Alaska. Steep slopes may be preferred by denning brown bears because they are drier and better drained, are easier to excavate and/or because they are usually in more remote areas or due to snow accumulation patterns.

Den aspect does not appear to be a primary factor in site selection. Forty-four percent of the dens had northerly exposures, 29% had southerly exposures, 25% had westerly exposures and 2% had easterly exposures (Table 7). On the central Alaska Peninsula Lentfer et al. (1972) found bears preferred easterly exposures but that factors influencing this choice was not apparent. On Kodiak Island, bears preferred either northerly (Lentfer et al. 1972, Van Daele et al. 1989) or southerly exposures (Van Daele et al. 1989) while southerly exposures were favored in southeast Alaska (Schoen et al. 1987) It appears from this and other studies that orientation to azimuth does not explain den site selection.

Most bear denning was concentrated, probably due to the availability of preferred habitat. Fifty-four percent of collared bears denned in high concentration, 15% in medium concentration and 31% in low concentration areas. Areas of high denning concentration were selected by 48% of 39 collared

females and 33% of nine males. High concentration denning areas were selected by 59% of maternal females and 53% of non-maternal females. Most denning was concentrated into 2 small geographic areas in the core of the study area. Thirty-six (75%) of the dens of collared bears were found in 1.6% (32.3 km^2) of the study area. At 1 Kodiak Island study site 184 (36%) of marked bear dens were found in 1% (7.8 km^2) of the area (Van Daele et al. 1989).

Preferred denning areas were precipitous, geographically remote locations with difficult access. Human disturbance such as hunting and low-level aircraft overflights are less frequent in such areas. These factors, in addition to site specific habitat characteristics may affect den site selection and concentration. Craighead and Craighead (1972) suggested that grizzly bears prefer remote den sites away from areas of human disturbance.

Schoen et al. (1987) found that helicopter activity associated, with mining operations in southeast Alaska, caused radio-collared bears to seek more remote den sites in subsequent years. Helicopter activity caused 5 grizzly bears in northern Alaska to abandon den sites (Reynolds et al. 1976).

Collared bears exhibited a high degree of fidelity for previously used denning areas. Eight females, tracked to dens in different

years, selected sites averaging 1.4 km (range 0.5 to 3.6) apart while dens of 3 males averaged 4.4 km (range 0 to 19.2) apart. No significant difference ($P > 0.05$) was found in den site fidelity of females versus males. Schoen et al. (1987), found that collared male brown bears in southeast Alaska, denned significantly farther apart in subsequent years than did females. Van Daele et al. (1989) reported that 49% of 162 den sites of collared bears on Kodiak Island were less than 1 km from sites selected by the same individuals in previous years and that males showed much less den site fidelity. High den site fidelity found in this and other coastal brown bear studies shows the importance of geographically restricted denning areas to large proportions of individual populations.

HOME RANGE

Home range size varied (3.2 to 47.2 km^2), with average home ranges for 6 males significantly larger than for 16 maternal females ($P < 0.05$) but not larger than for all 29 females combined ($P > 0.10$) (Table 8 and 9). Average home ranges for 16 maternal females ($\bar{x} = 8.6$ km^2) and 13 non-maternal females ($\bar{x} = 12.3$ km^2) were not significantly different ($P > 0.05$). Home ranges for maternal females with cubs-of-the-year, yearlings and 2.5 year old cubs were significantly different ($P < 0.05$) only

for females with cubs-of-the-year ($\bar{x}$ = 6.3 km^2) versus those with 2.5 year old cubs ($\bar{x}$ = 17.6 km^2) (Table 9).

Average home range sizes of radio-collared adults of both sexes and for females with various age cubs suggested over a 10-fold decrease in geographic requirements for bears in this study versus other investigations along the Alaska Peninsula (Dau 1989, Glenn 1976). Comparatively small home range sizes are the result of the compressed geographic characteristics of the study area where seasonal foraging areas, cover and denning sites are in close proximity. Numerous other studies have also indicated that movements and resulting home range size are affected by the spatial relationship of required habitats (Pearson 1975, Ballard et al. 1982, Reynolds 1980, Reynolds and Hechtel 1986).

MANAGEMENT RECOMMENDATIONS

The characteristics of the study area are unique in comparison with the remainder of the lower Alaska Peninsula in that the diversity of habitats necessary to sustain the high density brown bear population are compressed into a relatively small geographic area. Historically, the area remained pristine due to difficulty of access by people interested in public use or commerical development. Special management strategies may be appropriate to insure the intregity of habitats and populations within the area.

The small home ranges determined for radio marked bears underscores the fact that critical habitat requirements for a large number of bears are available in a relatively small area. An estimated density, of 0.73 bears/km^2 for this study area approximates the 0.65 to 0.85 bears/km^2 for high density study sites on Kodiak Island (Troyer and Hensel 1964; Atwell et al. 1980). Areas of human habitation and associated disturbance within 15 kilometers of the study area supported a much lower density of approximately 0.05 bears/km^2 (Dau 1989). The high density of adult bears and good annual recruitment of young adult female component of the population represents a broad spectrum of age cohorts and that these animals are relatively sedentary.

Two basic management concerns seem apparent with this population. First, the integrity of the diverse habitats within the study area may be compromised by various forms of activity or potential development. Maintenance of these habitats is essential to ensure stability of the core population and very likely the numbers of bears in peripheral areas of lower density. Secondly, the interest in brown bears by consumptive and non-consumptive users is increasing thereby necessitating more intensive management of various forms of public use such as hunting and wilderness camping.

Most relocations of marked bears during non-denning (98.3%) and denning (94.1%) periods were on refuge lands (Fig. 3). Lands within the Izembek Unit of the Izembek National Wildlife Refuge are designated Wilderness. Forty-one percent of the study area is included in the Izembek Unit. In addition, 34% of the study area, within the Pavlof Unit of the refuge, has been proposed for Wilderness designation. This would provide additional protection and, in addition to Izembek Unit lands, include essentially all identified denning habitats and the most important summer and fall foraging areas under Wilderness designation. The concentrated pattern of denning supports the increased need to protect these critical habitats from adverse forms of disturbance or development. Native Corporation lands, conveyed and selected (Alaska National Interest Lands Conservation Act 1980), comprise 47% of the study area (Table 1). Native Corporation selected lands occur within refuge boundaries and some or all will not be conveyed. Lands owned by the State of Alaska comprise 7% of the study area. Native or State lands could be proposed for development activities that may detrimentally impact brown bear populations or their habitats.

The entire study area is suitable for Wilderness designation and those Federally owned lands should be included within the Wilderness Preservation System. Additionally, efforts should be made by the U.S. Fish and Wildlife Service to work closely with

State and private landowners with the goal of identifying cooperative management programs which consider the requirements of brown bears and their habitats. Public use of brown bears and their habitats, primarily consumptive use by big game guides and hunters, must also be managed to insure both the physical integrity of the area and the continued opportunity for various forms of public use.

LITERATURE CITED

Atwell G., D.L. Boone, J. Gustafson and V.D. Berns. 1980. Brown bear summer use of alpine habitat on the Kodiak National Wildlife Refuge. Int. Conf. Bear Res. and Mange. 4: 297-305.

Ballard, W.B., Miller, S.D. and T.H. Spraker. 1982. Home range, daily movements and reproductive biology of brown bear in southcentral Alaska. Can. Field Nat. 96:1-5.

Barnes, V.G. Jr. 1985. Progress Report. Brown Bear Studies - 1984. U.S. Fish and Wildlife Service, Denver Wildlife Research Center. 38pp.

_____. 1990. The influence of salmon availability on brown bear movements in southwest Kodiak Island. Int. Conf. Bear Res. and Manage. 8:305-313.

_____, R.B. Smith and L.J. Van Daele 1988. Density estimates and estimated population of brown bears on Kodiak and adjacent islands, 1987. Unpublished report to the Kodiak Brown Research and Habitat Maintenance Trust. Anchorage, AK. 34 pp.

Brophy, J.G. 1984. The chemistry and physics of Aleutian Arc volcanism: the Cold Bay volcanic center southwestern Alaska. PhD. thesis, John Hopkins University. 422 pp.

Craighead, F.C., Jr. and J.J. Craighead 1972. Grizzly bear pre-hibernation and denning activities as determined by radio tracking. Wildl. Monog. 32. 35 pp.

Dau, C.P. 1989. Management and biology of brown bears at Cold Bay, Alaska. Bear-People Conflicts - Proc. of a Symposium on Management Strategies. Northwest Territories Dept. of Renew. Res. p. 19-26.

Erickson, A.W., and D.B. Siniff. 1963. A statistical evaluation of factors influencing aerial survey results on brown bears. Trans. N. Amer. Wildl. Conf. 28:391-409.

Glenn, L.P., and L.H. Miller. 1980. Seasonal movements of an Alaska Peninsula brown bear population. Int. Conf. Bear Res. and Manage. 3:306-312.

Lenfer, J.W., R.J. Hensel, L.H. Miller, L.P. Glenn and V.D. Berns. 1972. Remarks on denning habits of Alaskan brown bears. Int. Conf. Bear Res. and Manage. 2:125-137.

Marlow, M.R. and A.K. Cooper. 1984. Summary geologic report for the North Aleutian Shelf (OCS) planning area, Bering Sea, Alaska. USDI- Geological Survey Open File Report 84-773. 29 pp.

Mohr, C.D. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Pearson, A.M. 1975. The northern interior grizzly bear (Ursus arctos). Can. Wildl. Ser. Report No. 34. 86pp.

Reynolds, H.V., J.A. Curatolo and R. Quimby. 1976. Denning ecology of grizzly bears in northeastern Alaska. Int. Conf. Bear Res. and Manage. 3:403-409.

Reynolds, H.V. 1980. North slope grizzly bear studies. Vol. 1. Alaska Dep. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-11. 65pp.

_____, and J.L. Hechtel. 1986. Population structure, reproductive biology and movement patterns of grizzly bears in the northcentral Alaska Range. Alaska Dep. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-21-2, W-22-2, W-22-3 and W-22-4. 53pp.

Reynolds, P.E., H.V. Reynolds and E.H. Follmann. 1986. Responses of grizzly bears to seismic surveys in northern Alaska. Int. Conf. Bear Res. and Manage. 6:169-175.

Schoen, J.W., Lentfer, J.W. and L. Beier. 1986. Differential distribution of brown bears on Admiralty Island, southeast Alaska: A preliminary assessment. Int. Conf. Bear Res. Manage. 6:1-5.

_____, Beier, L., Lentfer, J.W. and L.J. Johnson. 1987. Denning ecology of brown bears on Admiralty and Chichagof Island. Int. Conf. Bear Res. Manage. 7:293-304.

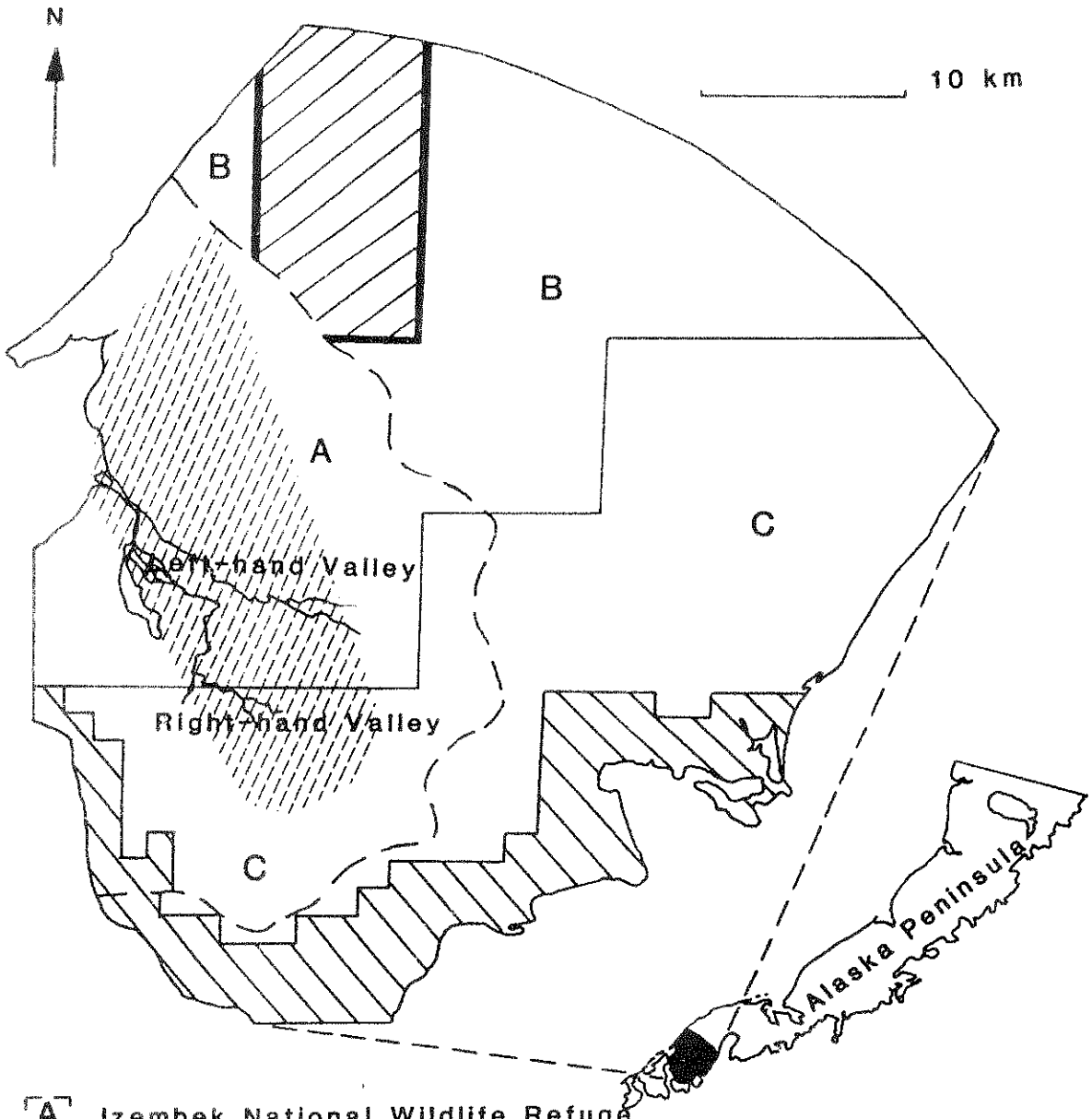
Smith, R.B. and L.J. Van Daele. 1988. Terror Lake hydroelectric project. Final report on brown bear studies. 1982-1986. Alaska Department Fish and Game. Kodiak, Alaska. 195 pp.

Troyer, W.A. and R.J. Hensel. 1964. Structure and distribution of a Kodiak bear population. J. Wildl. Manage. 28(4):769-772.

USFWS. 1985. Alaska Peninsula National Wildlife Refuge. Comprehensive Conservation Plan/Environmental Impact Statement. U.S. Fish and Wildlife Service, Anchorage, Alaska. 426 pp.

Van Daele, L.J., Barnes, V.G., Jr., and R.B. Smith. 1990. Denning characteristics of brown bears on Kodiak Island, Alaska. Int. Conf. Bear Res. Manag. 8:257-267.

Fig. 1. Boundaries of brown bear study area.



A Izembek National Wildlife Refuge, Izembek Unit(Wilderness)

B Izembek National Wildlife Refuge, Pavlof Unit(Proposed Wilderness)

State of Alaska

Native Corporation (Conveyed)

Bear Capture Area

C Native Corporation (Selected)

Fig. 2. Brown bear use relative to available habitat.

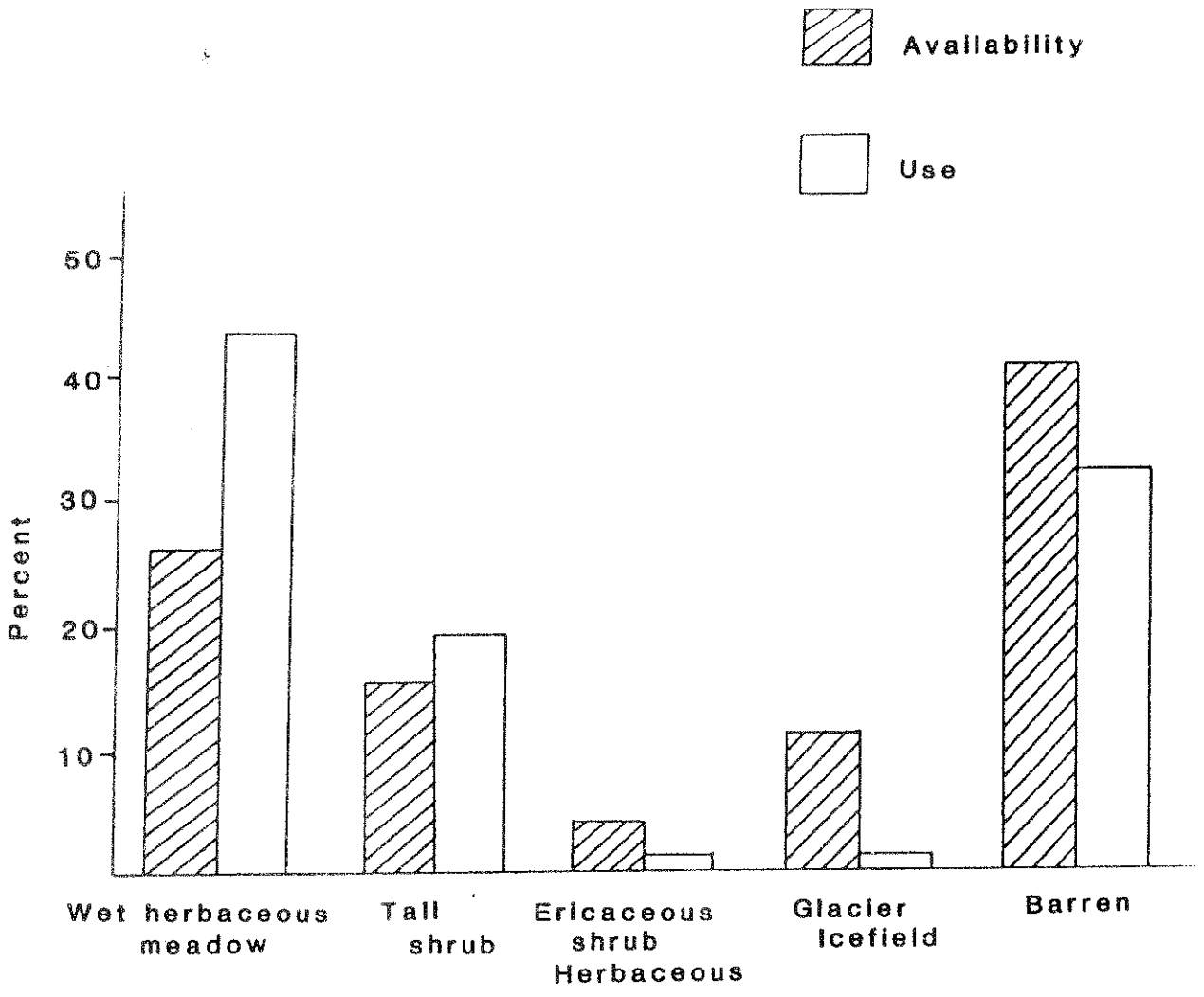
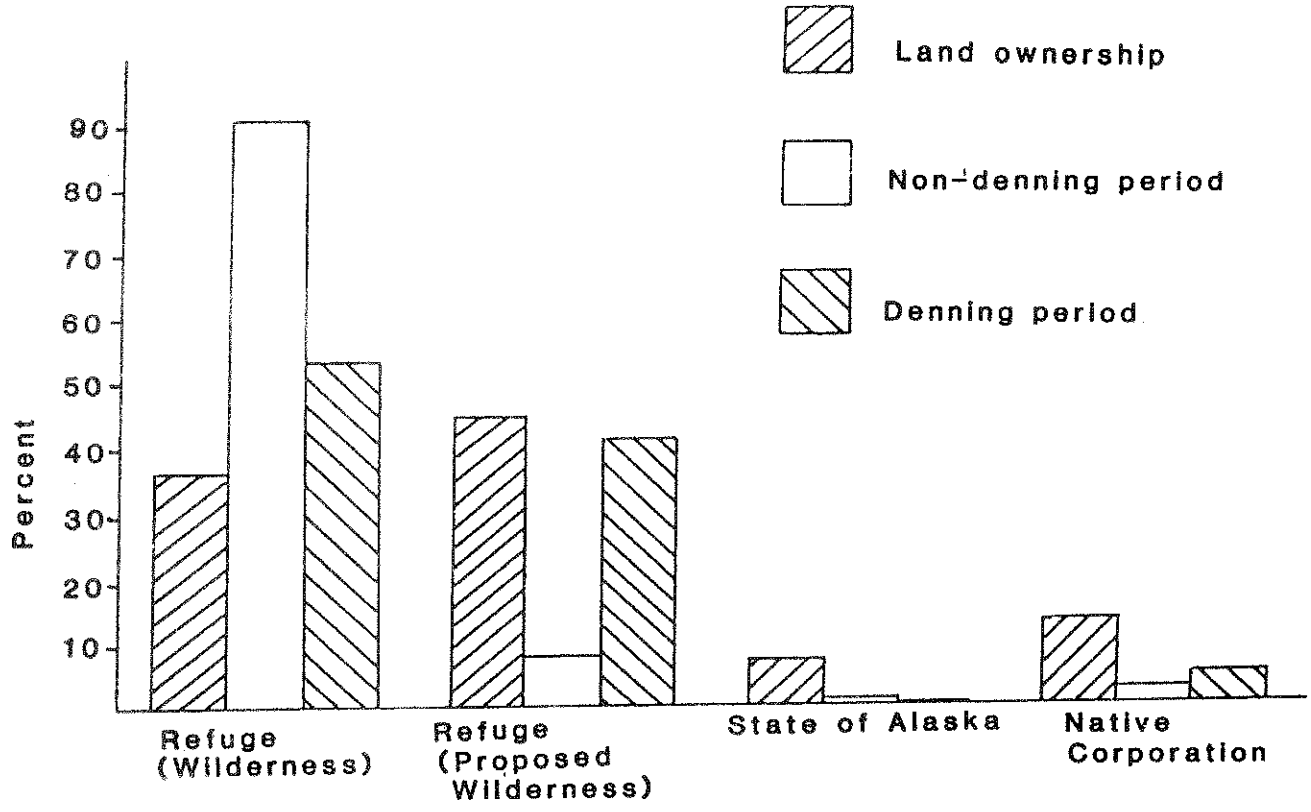

Availability
Use
Percent
50
40
30
20
10
Wet herbaceous meadow
Tall shrub
Ericaceous shrub Herbaceous
Glacier Icefield
Barren

Fig. 3. Seasonal relocations of radio-marked bears relative to land ownership.


Land ownership
Non-denning period
Denning period
Percent
90
80
70
60
50
40
30
20
10
Refuge (Wilderness)
Refuge (Proposed Wilderness)
State of Alaska
Native Corporation