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NORTH SLOPE

GRIZZLY BEAR STUDIES

BY

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VOLUME I

Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-11, Jobs 4.14R and 4.15R

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JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperators:	Harry V. Reynolds and John Hechtel		
Project No.:	W-17-11	Project Title:	Big Game Investigations
Job No.:	4.14R	Job Title:	Structure, Status, Reproductive Biology, Movement, Distribution, and Habitat Utilization of a Grizzly Bear Population
Period Covered:	July 1, 1978 through June 30, 1979		

SUMMARY

Population biology, movement, distribution, and habitat utilization of grizzly bears were studied during 1977-1979 in the northern foothills of the western Brooks Range. Eighty-eight of the estimated 119 bears in the 5,200 km^2 (2,000 mi^2) study area were captured. A density of 1 bear/43 km^2 (1/17 mi^2) was estimated in the area. The age structure of the population showed more animals in the 0.5- to 2.5-year age classes than in any others. The sex structure of that portion of the population over 1.5 years of age was 60.2 percent females and 39.8 percent males. Measures of reproductive biology which were calculated included: a mean age of 8.4 years at first production of a litter, a reproductive interval of 4.03 years, a mean litter size of 2.03 young, and a reproductive rate of 0.503 cubs/female/year. Evidence indicates that these parameters are higher than those reported in other portions of the North Slope, probably due to the availability of carrion and prey from calving caribou of the Western Arctic Herd.

Twenty-one mortalities, primarily of young-age bears, were recorded. Evidence suggests most of these were caused by adult males.

The mean distance traveled per day by grizzly bears was observed to be 5.0 km (3.1 mi). The maximum movement by an individual was by a male which traveled 163 km (101 mi) to the coast of the Arctic Ocean and later returned. Home ranges were calculated for 26 grizzlies; mean home range size was 1,350 km^2 (521 mi^2) for males and 344 km^2 (133 mi^2) for females. Food habits and habitat use were investigated. Bears usually denned within their spring, summer, and fall ranges, but four individuals moved from 16.1 to 43.8 km (10.0-27.2 mi) from their fall ranges to den. The mean range of denning dates in 1977 was from 12 to 18 October and in 1978 it was from 7 to 9 October. Dens were located throughout the study area in all types of terrain and at elevations from 270 to 1,280 m (900 to 4,200 ft). Disturbance of denning bears by seismic exploration was monitored; no abandonment of dens was observed, but the potential for adverse impact exists, especially impact affecting females with newborn cubs.

CONTENTS

BACKGROUND

The history of brown/grizzly bears (*Ursus arctos*) has been one of continuous reduction of numbers and range, coinciding with human population growth and development. Only remnant populations remain in Europe (Cowan 1972, Curry-Lindahl 1972). In North America, where they once ranged throughout the western portion of the continent, populations are now much reduced or absent in most areas south of the Canadian border (Storer and Tevis 1955, Craighead and Craighead 1967, Cowan 1972, Herrero 1972). In the past, much of the North American brown/grizzly bear range has been protected by its rugged physiography or inaccessibility, but these obstacles to resource development and access no longer impede expansion of human activities.

The potential for adverse impact of development on grizzly bear populations in Alaska is probably greatest from the Brooks Range north to the Arctic Ocean. Here the grizzly is at the northern extent of its range; the period of food availability during the summer season is short, reproductive potential is low, the area required for individual home ranges is large, and the stunted vegetation of the region provides little cover (Reynolds 1976, Reynolds et al. 1976).

Brooks et al. (1971) pointed out the possible detrimental impacts that development of oil and gas resources might have on North Slope grizzlies, including disruption of habitat, increased human habitation, and increased access. Since then, construction of the Trans-Alaska Oil Pipeline has been completed, a road linking Fairbanks with the Arctic

Ocean coast has been finished, exploration for additional petrochemical reserves has increased, and plans for networks of transportation corridors throughout the area have been made. The exploitation of tremendous potential gas and oil reserves in National Petroleum Reserve-Alaska (NPR-A) would take place in the largest undeveloped area remaining on the North Slope. This is an area where loss of habitat or development-caused disruption of population dynamics could have undesirable consequences for grizzly bear survival or population maintenance.

Before the potential impact of increased resource development on grizzly bears in northwestern Alaska can be evaluated, it is necessary to determine basic biological information including sex and age structure, reproductive biology, movement patterns, home range size and population boundaries. Several studies have been conducted on the North Slope. R. L. Rausch (1969 and pers. comm.) studied some aspects of the sex and age structure of grizzly bears killed near Anaktuvuk Pass. Tentative estimates of abundance and productivity, instances of movement, and evaluation of survey techniques for grizzly bears were reported by Crook (1971, 1972) for the central North Slope. In 1973, studies were initiated to determine potential impact of development on the ecology of eastern North Slope grizzly bear populations (Quimby 1974, Quimby and Snarski 1974, Reynolds 1974, Reynolds 1976, Reynolds et al. 1976). In these studies the grizzly bear population density was found to be low (1 bear/140-260 km^2 or 1 bear/360-675 mi^2), home range size large, and reproductive potential low. It was not known whether these population parameters are region-wide or indicative only of the area studied. Regardless of the applicability, populations in the Arctic are more susceptible to impact from outside sources, including resource development, and, if adverse impact is to be avoided, a knowledge of grizzly bear habitat requirements and population dynamics is imperative.

In 1976 the U.S. Congress mandated an evaluation of oil and mineral potential on NPR-A in northwestern Alaska; studies to determine the impact of exploration and development on fish and wildlife species were funded at the same time. During 1977 and 1978 this study of grizzly bear ecology was funded as one of the environmental impact studies associated with the NPR-A exploration program (Reynolds 1978). Although the studies conducted during 1977-1978 resulted in gathering baseline data, an understanding of some aspects of the biology of grizzly bears requires continuity of research effort. The present investigations are designed to provide that continuity and to improve the precision of baseline data.

OBJECTIVES

To determine the structure, size, status, and reproductive biology of a grizzly bear population on the northern slope of the western Brooks Range, and to evaluate how potential impacts of energy resource development upon the grizzly bear population can be avoided or minimized.

To determine home range selection, movement patterns, distribution, denning characteristics, and habitat utilization of grizzly bear populations in the western Brooks Range.

PROCEDURES

During May-October 1977 and 1978, and May-July 1979, intensive studies were carried out in a 5,200 km^2 (2,000 mi^2) area in the mountains and foothills of the western Brooks Range. The boundaries of the study area were roughly: Archimedes Ridge (69°10'N latitude) on the north, the Kokolik River on the west, the crest of the Brooks Range on the south, and a line running from Thunder Mountain to the Utukok River (160°15'W longitude) on the east.

Field work was carried out from a tent camp at Driftwood Creek airstrip on the Utukok River (68°55'N latitude, 152°05'W longitude) from 1 May to 2 November 1977, from 12 May to 16 October 1978, and from 4 May to 26 October 1979.

Bears were captured with the use of a Bell 206B helicopter from 22 May to 7 July and 8 to 10 August 1977, from 7 June to 3 July 1978, and from 26 June to 1 July and 13 to 18 September, 1979. During the period that bears were captured, a Piper PA-18-150 (Super Cub) aircraft was used to locate grizzlies and to direct the helicopter with the immobilization crew to the site. In addition, the Super Cub was used to conduct surveys or make observations and to locate bears fitted with radio transmitters.

Capture procedures followed standard helicopter immobilization techniques used on grizzly bears in the eastern Brooks Range (Reynolds 1974, 1976). Bears were immobilized with Sernylan (phencyclidine hydrochloride, Bio-Ceutic Laboratories, St. Joseph, MO) and acepromazine maleate (Ayerst Labs, New York, NY) injected into the rump using Cap-Chur equipment (Palmer Chemical and Equipment Co., Douglasville, GA). All animals were measured, weighed (Appendix I), tattooed for permanent identification, ear-tagged, and marked with individually coded visual identification collars or ear flags as described by Reynolds (1974) (Appendix II). In addition, 34 bears were fitted with collars containing radio transmitters; collars of 5 bears instrumented in 1977 and 1978 were replaced in 1978 and 1979, respectively.

A first premolar tooth was extracted for determination of age based on cementum layering (Mundy and Fuller 1964, Stoneburg and Jonkel 1966, Craighead et al. 1970). The techniques used to section, stain, and mount teeth for age determination were described by Glenn (1972).

Whole blood was collected from femoral arteries using donor tubes and 150-cc vacuum plasma collection units (Travenol Laboratories, Forest Grove, IL) or 10-cc Vacutainers (Bection-Dickinson, Rutherford, NJ). Blood was centrifuged at the field station and sera were frozen for determination of the presence of *Brucella* antibodies, and for blood chemistry studies being conducted by Dr. M. Philo, University of Alaska, Naval Arctic Research Laboratory.

Fecal samples were collected to aid in determining seasonal food habits and are being analyzed in detail as part of a Masters of Science thesis.

Information on breeding biology was obtained by: 1) recording data on the size, coloration, and lactating condition of the mammae, condition of the vulva, baculum size, and position of the testes; 2) observing male-female pairing; and 3) recording the number of cubs and age structure of all family groups.

In 1978 the direct count method (Pearson 1976, Reynolds 1976, 1978) was used to determine the grizzly bear population size on the intensive study area. Densities found on the study area in conjunction with those found elsewhere on the North Slope (Crook 1971, Quimby 1974, Reynolds 1974, Curatolo and Moore 1975, Reynolds 1976) and in northern Canada (Pearson 1976) were used to extrapolate densities in NPR-A and arrive at a population estimate. Several other methods were considered but rejected because of erratic or less accurate results. The differential efficiency method (Caughley and Goddard 1972) for determining population size was used for grizzly bear populations in the eastern Brooks Range with no success (Reynolds 1976). Inadequate funding and logistical constraints precluded use of the Lincoln Index (Overton and Davis *in* Giles 1969). The feasibility of using random transect lines 2,250 km (1,400 mi) in total length in conjunction with intensively surveyed 2,296 km^2 (886 mi^2) quadrats was tested during caribou (*Rangifer tarandus*) survey flights, but the number of bears seen during these surveys was too low to be representative of the areas. Crook (1972) tested a survey technique along river valleys of the central North Slope and found that the results were too erratic to be statistically meaningful. Until a more accurate survey or census method is devised and tested, extrapolations based on bear densities found in areas and habitats of intensive study will give the best population estimate.

Movements and home range size were determined from resightings of marked grizzlies during aerial surveys, and from frequently relocating 34 animals fitted with radio transmitters (Telonics, Inc., Mesa, AZ). Radio-collared bears were relocated using a Super Cub aircraft equipped with a radio receiver-scanner and four-element, high-gain Yagi antennas mounted to the wing struts. Transmitter signals were received at distances up to 48 km (30 mi) under optimum conditions when the aircraft was at 1,500 m (5,000 ft) above ground level (AGL); more often, especially in mountainous terrain, flight level was 300 m (1,000 ft) AGL and signals were received from 5-13 km (8-20 mi) distance.

Radio-relocations were plotted on 1:250,000 scale topographic maps and relevant information was recorded. When possible, locations were determined visually every 4 or 5 days in 1977 and every 7 days in 1978 and 1979; however, other commitments or long periods of inclement weather sometimes increased intervals between sightings. When radio-collared bears were not visually located during flights because of adverse weather conditions, cover, or terrain, "fixes" were determined by triangulation or by abrupt changes in radio signal strength.

Home ranges were determined using two methods for comparative purposes: the modified "exclusive boundary strip" (Stickel 1954, Berns and Hensel 1972, Curatolo and Moore 1975, Reynolds 1976) and the "minimum home range polygon" (Craighead and Craighead 1972; Pearson 1975, 1976; Craighead 1976). In the modified exclusive boundary strip method, the mapped locations were overlaid by grid squares 4.83 km (3.0 mi) on a side or 23.3 km^2 (9.0 mi^2) in area, dimensions based on daily movements by bears. All grids including observation sites were connected by the shortest distance to other grids containing locations (Fig. 1); this was done because no observations were made during travel by a bear between location sites. In the minimum home range polygon method, the outermost observation sites plotted on maps for each individual bear were connected to form a convex polygon and the home range size was determined by measuring the enclosed area with a compensating polar planimeter (Figs. 2, 3, 4, and 5).

FINDINGS AND DISCUSSION

Because of the difficulties in capturing a large enough proportion of a grizzly bear population to accurately describe the dynamics and reproductive biology of that population, findings presented here should be viewed as preliminary and contingent upon collection of additional data. Also, parameters describing productivity, especially reproductive interval and survival of young, must be recorded during more than 3 years in order to be accurate. Although this research was conducted during 1977, 1978, and 1979, data collection effort was not as intense in 1979 as in 1977 and 1978. Therefore, in discussions of some aspects of population characteristics, particularly sex and age composition, the data presented characterize the situation as it occurred in 1978; even so, observations made in 1979 are included wherever possible.

Population Size

Eighty-eight bears were captured and marked in the area of intensive study; an additional 62 unmarked, but identifiable, individuals were observed in the study area. Also, to account for those bears which did not stay in the study area throughout the year, the proportion of the home range of each bear outside the study area was estimated; the sum of these fractional home ranges (9.45) was subtracted from the study area population. Also, at least 21 mortalities occurred during 1977-1979, leaving a minimum of 119 grizzlies in the study area.

The unmarked identifiable bears included 23 offspring of marked females, 9 unmarked females with 19 young, 1 unmarked female with 2 marked young, and 10 single individuals. All sightings of these unmarked bears were recorded throughout the summer; unmarked females with young

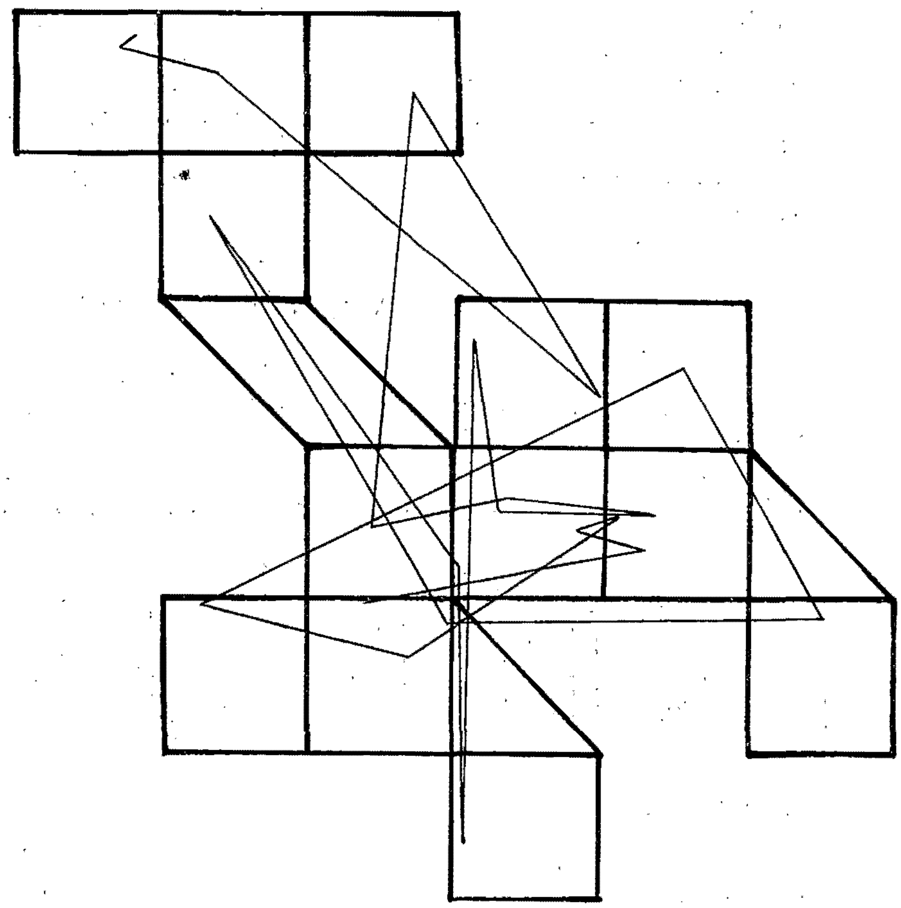

Fig. 1. Observed movement and home range size of grizzly bear No. 1097 in 1977, using the modified exclusive boundary strip method.

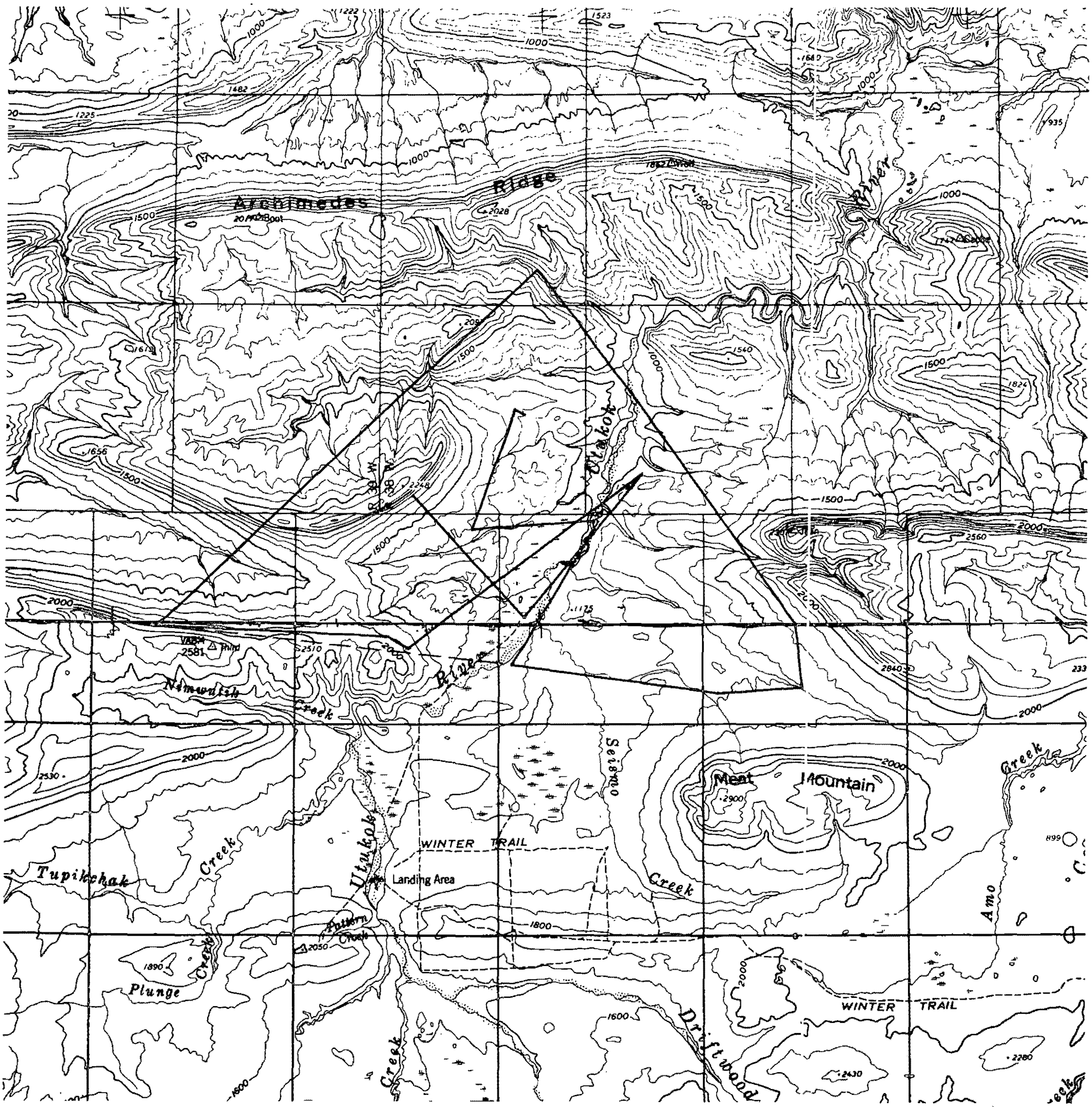

Fig. 2. Observed movement and home range size of grizzly bear No. 1097 in 1977, using the minimum home range method.

(broken spacing denotes boundary of minimum home range)

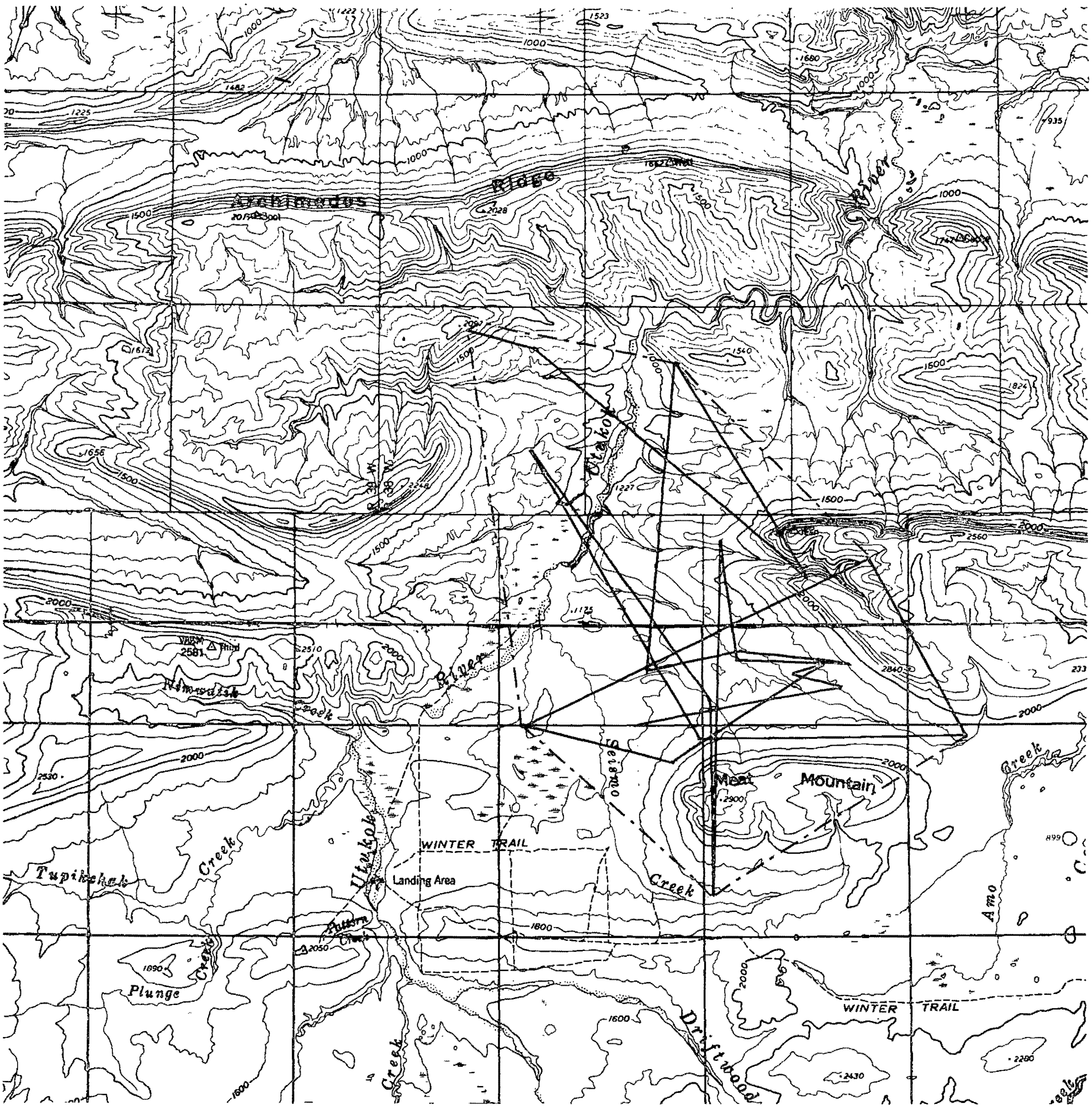

Fig. 3. Observed movement and home range size of grizzly bear No. 1097 in 1978, using the minimum home range polygon method.

(dotted lines denote boundary of home range)

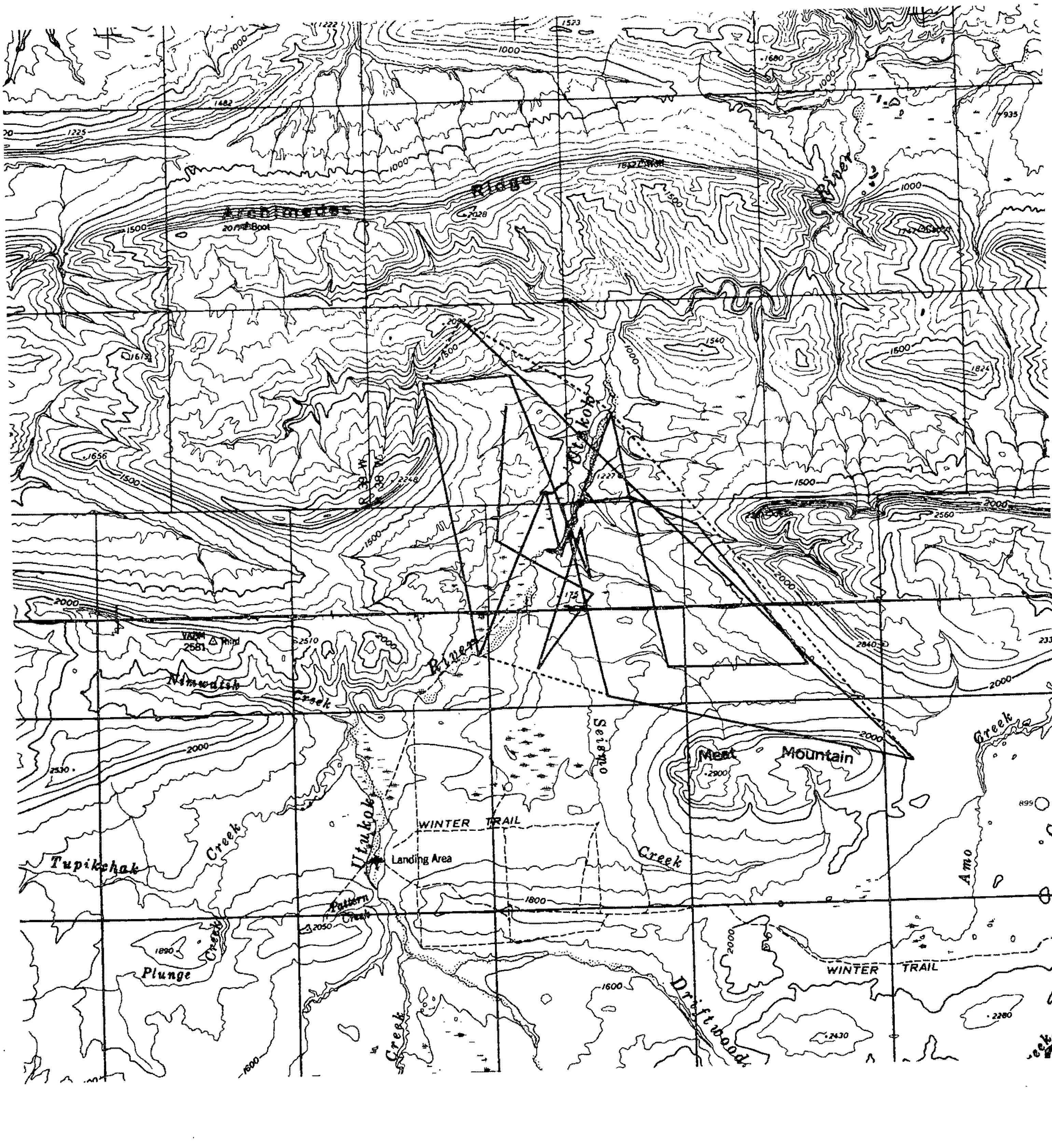

Fig. 4. Observed movement and home range size of grizzly bear No. 1097 in 1979, using the minimum home range polygon method.

(dashed lines denote boundary of home range)

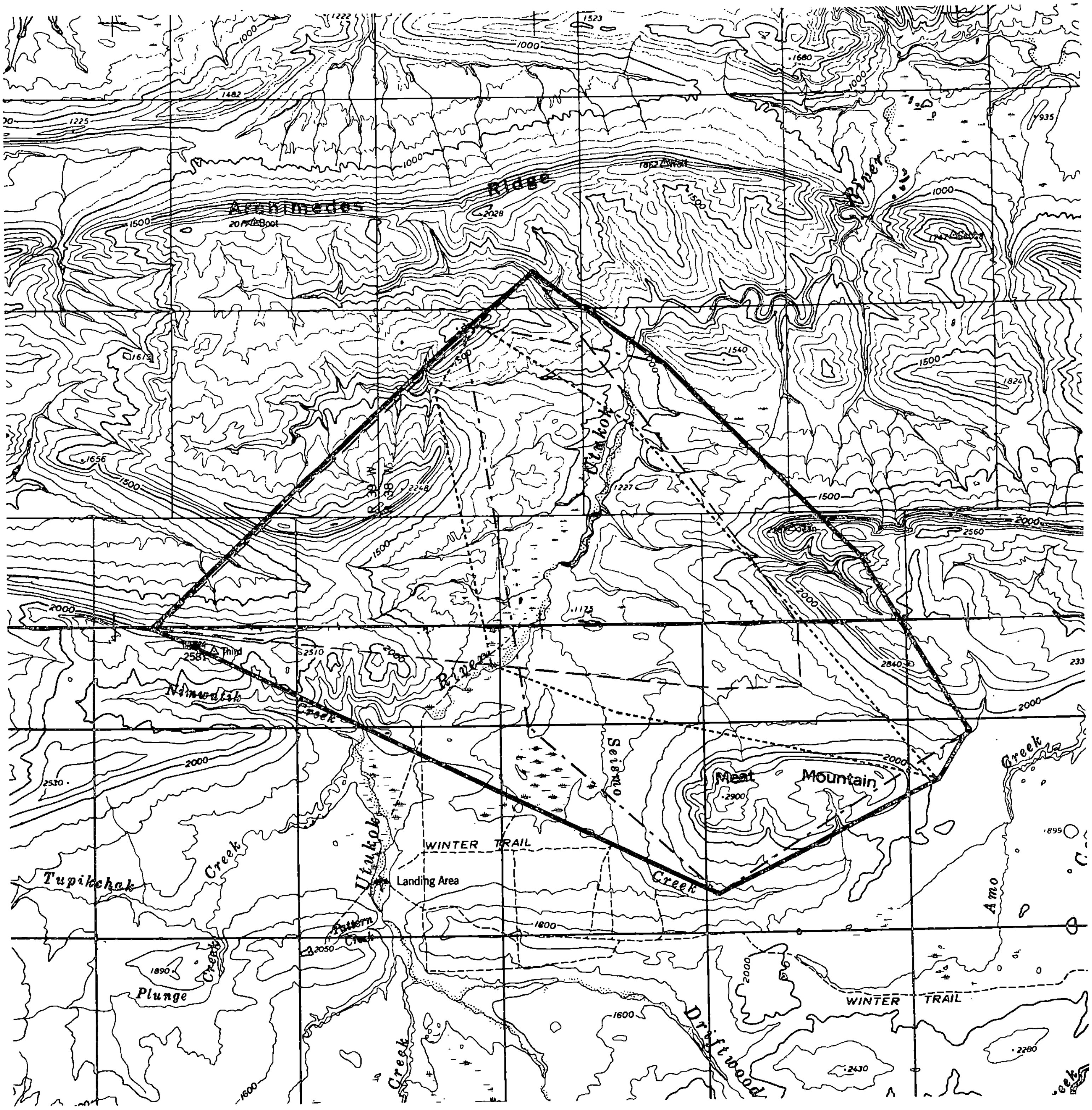

Fig. 5. Observed home range size of grizzly bear No. 1097 for 1977, 1978, 1979 and 1977-1979, using the minimum home range polygon method.

(solid lines denote the combined 1977, 1978, and 1979 home range boundary; broken spacing 1977 home range boundary; dotted lines, 1978 home range boundary; and dashed lines, 1979 home range boundary) could be identified with more precision than single bears since those bears were encountered in family groups of varying size, age and coloration of individuals within the groups, and their home ranges were generally smaller than those of single bears. It was more difficult to differentiate between individual solitary bears because of growth and pelage changes during the summer. However, a good minimum estimate of the number of solitary bears was obtained from observations of bears of the same size and coloration which were found repeatedly in the same vicinity, and from separate sightings of bears with similar descriptions which were seen within short periods of time or in widely separated locations. The accuracy of these techniques was illustrated when almost all bears captured in 1978 had been previously observed and accounted for in the 1977 estimate. The animals captured in 1978 which were not seen in 1977 were primarily cubs born in 1978. The intensity of effort was reduced in 1979, resulting in the location of fewer bears, however, the results indicated the population was essentially unchanged.

A density of 1 bear/44 km^2 (1 bear/16.9 mi^2) was calculated from the observed minimum population of 119 bears in the 5,200 km^2 (2,000 mi^2) area. Because of the lack of escape cover and extensive aerial surveys conducted for 2 years in the study area, it was felt that at least 95 percent of all bears in the study area were located. Therefore, an estimated adjusted population mean of 125 bears inhabited the area during the period 1977-1979, or a density of 1 bear/42 km^2 (1 bear/16.1 mi^2).

The best method for determining grizzly bear density or population size in Arctic regions has been a direct count in conjunction with an intensive individual marking program over a period of years (Reynolds 1974, 1976; Pearson 1975, 1976). Other means of estimating the grizzly bear population in areas not under intensive study have not been successful in the past because of grizzlies' low density, sparse distribution, and solitary habits (see Procedures section). However, even though the direct count method was felt to give accurate results, its use is limited to areas of intensive study and requires at least 2 years of data. Because studies of this intensity are not practical over large areas, the technique of assigning densities based on those found in habitat types in smaller areas of intensive study and extrapolating these figures over wide areas was applied to project the population size in NPR-A. Although these extrapolations were designed to answer impact-related questions for NPR-A studies, the principle involved can be applied in other portions of the state and used as an aid in determining management strategies.

Using this technique, an estimate of 420 grizzly bears was derived for NPR-A. This population size was calculated by estimating bear densities in the following strata: 1) the coastal plain (sea level to 1,000 ft mean elevation); 2) the low foothills (1,000-2,000 ft); 3) the high foothills (2,000-3,000 ft mean elevation); and 4) the mountains (elevations over 3,000 ft) and extrapolating these density estimates to total populations for the areas contained in each elevational category (stratum).

The estimated densities of bears in these strata are: coastal plain - 1 bear/780 km^2 (300 mi^2); low foothills - 1 bear/90 km^2 (35 mi^2), range - 1/50-1/130 km^2 (20-50 mi^2); high foothills - 1 bear/130 km^2 (50 mi^2); and mountains - 1 bear/260 km^2 (100 mi^2). These estimates are based on densities determined in the study area in southwestern NPR-A, those from the central Brooks Range (Crook 1971), and from the eastern Brooks Range (Curatolo and Moore 1975, Reynolds 1976). Although future research may result in more precise density estimates for these areas, the present estimates of numbers for 1979 have a sound basis and should be adequate for present management concerns.

By comparison, the grizzly bear population studied in the mountains and foothills of the eastern Brooks Range 500 km (310 mi) to the east of the study area had a density of 1 bear/148 km^2 (57 mi^2) (Curatolo and Moore 1975, Reynolds 1976). Possible explanations for these differences are discussed in the following sections.

Sex and Age Composition

Thirty-eight males (43.2%) and 50 females (56.8%) were captured during this study. These figures, however, probably do not reflect the true sex ratio of the population since 10 identifiable unmarked females with young, 3 adult males, 2 adult females, and 6 single bears of unknown sex were not included in these data. If those unmarked bears of identifiable sex over the age of yearlings are included with marked bears, 41 (39.8%) were males and 62 (60.2%) were females. Of 32 cubs and yearlings observed in the study area in 1978, only 12 were marked and their sex ratio was equal. This situation is similar to that found in Wyoming (Craighead et al. 1974) and may be explained by the fact that males, especially young individuals, range more widely than females and are more prone to various mortality factors. Hunting pressure in the area is very low and most mortality is due to natural factors.

The sex and age distribution of marked and unmarked bears in the study area in 1978 is presented in Table 1. Sex of marked bears was recorded after direct observation. To facilitate analysis, all bears were assigned the ages they would have reached in 1978, regardless of their year of capture. Similar data were collected in 1979 but, since the research effort was not as intense, information concerning the composition and survival of each age cohort was not as accurate as in 1978. One difference observed in 1979 which did not occur in 1977 or 1978 was that, although a minimum 15 cubs were produced, by mid-July only six were still alive. This observed survival represents a much lower cub cohort size than was recorded for the previous 2 years. Whether this difference represents a recurring situation is unclear, but without the greater production and survival of cubs which occurred in 1977 and 1978 the population could not be maintained at its present size. The age distribution indicates that there are more females than males in the adult cohorts and that these females appear to have a longer life expectancy.

Table 2 shows a comparison of age distribution in the study area with populations in the eastern Brooks Range (Reynolds 1976) and Yellowstone

Table 1. Age and sex structure of the grizzly bear population in the study area in the western Brooks Range, 1978.

Age by Cementum	Males	Females	Unmarked, Sex Unknown	Total Known in Age Class*
0.5	3	1	15	19
1.5	3	5	6	14
2.5	6	7	5	18
3.5	2	3	2	7
4.5	1	2		3
5.5	5	2		7
6.5	4	1		5
7.5	0	4		4
8.5	3	3		6
9.5	2	4		6
10.5	1	1		2
11.5	1	1		2
12.5	0	3		3
13.5	0	0		0
14.5	2	1		3
15.5	0	3		3
16.5	0	0		0
17.5	2	1		3
18.5	1	1		2
19.5	0	1		1
20.5	2	1		1
21.5	0	0		0
22.5	0	1		1
23.5	0	0		1
24.5	0	1		1
25.5	0	1		1
26.5	0	0		0
27.5	0	1		1

* Ages were either assigned after observation of individuals as cubs, yearlings or 2-year-olds when they were accompanied by adult females or established from premolar tooth cementum annuli. In addition, the sexes and ages of 19 unmarked bears were estimated. Based on size, pairing during the breeding season or accompaniment by offspring, the sex and age of unmarked bears on this study area were as follows: 2 of unknown sex were 2.5-3.5 years of age, 4 from 4.5-6.5 years of age, and 10 females and 3 males were estimated older than 6.5 years of age.

Table 2. A comparison of age cohorts of grizzlies in three populations.

Location	Percent Cubs	Percent Yearlings	Percent 2-yr-olds	Percent 3 and 4 yr-olds	Percent 5-yr-olds and Older	Status of Population
Yellowstone Park (Craighead et al. 1974)	18.6	13.0	10.2	14.7	43.7	increasing
Eastern Brooks Range (Reynolds 1976)	7.9	10.9	10.9	5.0	65.3	declining*
Western Brooks Range (1978, present study)	13.0	10.7	13.7	10.7	51.9	unknown

* Based on reproduction and age distribution data.

National Park (Craighead et al. 1974). In the Brooks Range the proportion of cubs is low but survival of the next two successive cohorts appears to be high. In Yellowstone the population has a high proportion of cubs and is increasing even though survival of young age cohorts is low.

Reproductive Biology

To determine the reproductive rates for bears, the following parameters of reproductive biology must be known: age at first production of young, length of productive life of females, length of the reproductive cycle or reproductive interval and average litter size (Craighead et al. 1974). In Alaska, the age at sexual maturity for brown/grizzly bears has ranged from 3.5 to 6.5 years on the Alaska Peninsula and Kodiak Island (Hensel et al. 1969, Glenn et al. 1976) and 6.5 to 12.5 years in the eastern Brooks Range (Reynolds 1976). In the Yukon Territory, Pearson (1972) concluded that females are first capable of conception at 6.5 years in the southwestern portion of the territory and at 7.5 years in the northern portion. In Yellowstone National Park, Craighead et al. (1969) reported that females bred at 4.5 to 8.5 years of age and had their first cubs the following spring. Moreover, they observed that some 3.5-year-old females copulated but none bore cubs the following spring.

Although the age at first pregnancy is probably the most accurate measure of age at sexual maturity, the occurrence of pregnancies is not easy to establish. In wild populations intrauterine mortality or mortality in the den prior to spring emergence is difficult to ascertain. Also, pregnancy does not necessarily follow breeding. Observations of females in estrous condition at least 2 years prior to their first successful production of young were recorded in three instances in the study area and have been recorded in Wyoming (Craighead et al. 1969) and Alaska (Glenn et al. 1976, Reynolds 1976).

For these reasons, the age at which a female produces her first litter that survives until after the emergence of the family group from the den is defined as the beginning point of a female's productive life or the minimum age at first production of young. The condition, size, and coloration of mammae are good indicators of past production or non-production of young (Lentfer et al. 1969, Glenn 1972, Reynolds 1976). For example, the mammae of a female which has not produced young are typically 10 mm in length, pinkish-grey in color, are unwrinkled and show no scarring on the areola. Producing females have mammae which are usually about 14 mm long, black, and flaccid, often showing scarring near the areola.

The minimum age at first production of young for females was established at 6.5 years of age in the study area. Nevertheless, at least one female had not produced young at 9.5 years of age. (She had bred and become pregnant at age 5.5.) No other females of age 5.5 years were determined to have bred. For this reason, the mean age at first production of young should be used in calculation of reproductive potential rather than the minimum age. During this study 15 females accompanied by young were captured (Table 3); 1 female had cubs at 6.5 years, 2 at 8.5 years, and 12 between 10.5 and 25.5 years. Of the 15 which were not accompanied by young when captured, six had produced young in the past and nine had not. If these six females had successfully reared young, weaned them as 2-year-olds and been captured during the same summer in which weaning occurred, one female would have first produced young at age 7.5 and the others at 11.5 years or older. Of those nine bears whose mammae did not display evidence of rearing young, four later had their first litters at ages 6.5, 8.5, 9.5 and 10.5 years; the earliest ages at which the other nine nonproducing females could have young would be 7.5 (1), 8.5 (3) and 10.5 (1).

Assuming that: 1) all females over age 7.5 years which showed no previous evidence of rearing young conceived during the year of calculation; 2) those females which showed previous evidence of having young were captured during the year in which their young were weaned as 2-year-olds; and 3) young accompanied by females of ages 8.5 or 9.5 were the product of their first successful birth, then an average minimum age of 8.4 years at first successful production of cubs can be calculated from 11 individuals. It should be noted this is a minimum figure since assumptions 1) and 2) create a bias toward a younger age; data strongly indicate little bias exists in assumption 3.

Female grizzly bears in the western Brooks Range are potentially long-lived. The ages of the six oldest females at the time of capture, as established by examination of premolar tooth cementum annuli, were 18.5, 19.5, 21.5, 23.5, 24.5, and 26.5. All of these females were accompanied by young or were in estrous condition during the study. Their ages and reproductive status during the study were as follows: four produced cubs at 17.5, 21.5, 21.5 or 22.5, and 25.5; one bred at 19.5 and 20.5 years but did not produce young; and one bred at 26.5 but was not observed the following year. Thus, females may potentially be reproductively active from age 6.5 to 25.5, a period of 19 years. In comparison, observations of maximum reproductive age were recorded at age 25.5 in Yellowstone Park (Craighead et al. 1974), 21.5 years in the northern Yukon (Pearson 1976), and 22.5 years in the eastern Brooks Range (Reynolds 1976).

The term, length of the reproductive cycle, or reproductive interval, as used in the study was the time between breeding and weaning of offspring, regardless of whether breeding resulted in production of offspring. For purposes of calculation, initial breeding was assumed to take place at age 7.5 years, based on the mean age at first production of young at 8 years of age. Although intervals for individual bears were established in some instances, accurate determination of an average reproductive interval for a species with such a low reproductive rate as grizzly bears requires observation of a population over a longer period of time than was possible in this study. An example of the importance of gathering long-term data occurred during this study. In midsummer 1977, of 20 marked or identifiable females with offspring, only one

Table 3. Litter size and reproductive status for female grizzlies in the western Brooks Range.

Bear No.	Age in 1979	Offspring No.	1975	1976	1977	1978	1979	Reproductive History
1085	21.5	--	--	--	B	B	NB?	offspring prior 1977
1086	18.5	1087, 1164	B	2 cubs	2 yrlg	2 2-yr	2 3-yr/B	
1089	6.5	2UM	--	--	NB	B	2 cubs	no offspring prior 1977
1090	20.5	3UM	B	3 cubs	3 yrlg	3 2-yr	3 3-yr/?B	
1092	10.5	1093	--	B	1 cub	1 yrlg	1 2-yr	
1095	8.5	none	--	--	?B	?B	--	no offspring prior 1977
1097	10.5	2UM	--	--	B	B	2 cubs/B	no offspring prior 1977
1100	8.5	2UM	--	--	NB	B	2 cubs/B	no offspring prior 1977
1102	4.5	none	--	--	NB	NB	?B	no offspring prior 1977
1104	11.5	1101?, 1102?; 1UM; 1UM	2 cubs?	2 yrlg?	2 2-yr?/B	1 cub/B	1 cub/B	1101, 1102 probable offspring
1105	9.5	1UM	--	--	B	B	1 cub/B	no offspring prior 1977
1106	13.5	1107, 1108, 1109	--	B	3 cubs	2 yrlg	DEAD	mortality: 1 yrlg 1978; 1106 (& 2 2-yr?) 1979
1110	26.5	1160, 1161	--	--	B	2 cubs	2 yrlg	offspring prior 1977
1111	16.5	1112, 1113; 3UM	2 2-yr	2 3-yr	2 4-yr/B	B	3 cubs/B	
1118	19.5	2UM	--	--	B	2 cubs	2 yrlg	offspring prior 1977
1119	8.5	--	--	--	B	B	--	no offspring prior 1977
1121	13.5	1122, 1123	--	B	2 cubs	2 yrlg	--	
1127	28.5	--	--	--	B	--	--	offspring prior 1977
1128	9.5	1129; 3UM cubs	B	1 cub	1 yrlg/B	3 cubs	--	
1130	23.5	2UM	--	B	2 cubs	1 yrlg	--	mortality: 1 cub/yrlg 1977-78
1134	16.5	1135, 1136, 1137	B	3 cubs	3 yrlg	2 2-yr	--	mortality: 1 2-yr 1978
1138	25.5	1151, 1152, 1153	B?	2 yrlg, 1 cub	2 2-yr, 1 yrlg	2 3-yr, 1 2-yr	--	possible adoption of young
1139	12.5	1140, 1141	--	--	B	2 cubs	2 yrlg	
1142	15.5	--	--	--	--	B	--	offspring prior to 1978
1143	10.5	1144, 1UM	--	B	2 cubs	2 yrlg	2 2-yr	
1146	15.5	1145, 1UM?	B	1-2 cubs	1-2 yrlg	1 2-yr	1 3-yr/B	probable yrlg mortality
1154	13.5	1155	--	B	1 cub	1 yrlg	1 2-yr	

Table 3. Continued.

Bear No.	Age in 1979	Offspring No.	1975	1976	1977	1978	1979	Reproductive History
1156	7.5	none	--	--	--	B	--	no offspring prior 1978
1158	8.5	none	--	--	--	B	--	no offspring prior 1978
1166	9.5	none	--	--	--	--	?B	no offspring prior 1979
1167	10.5	1168	--	--	--	B	1 cub	
UM	--	2UM	--	B	2 cubs	2 yrlg	--	
UM	--	3UM	--	--	B	3 cubs	--	possible mortality: 1 cub 1978
UM	--	2UM	--	--	B	2 cubs	2 yrlg	
UM	--	2UM	--	--	B	2 cubs	--	
UM	--	2UM	--	B	2 cubs	--	--	
UM	--	1162, 1163	B	2 cubs	2 yrlg	2 2-yr/?B	--	
UM	--	3UM	B	3 cubs	3 yrlg	--	--	
UM	--	2UM	2 cubs	2 yrlg	2 2-yr	--	--	
UM	--	3UM	--	--	--	B	3 cubs	
UM	--	2UM	--	--	B	2 cubs	2 yrlg	

* Designations are as follows: UM=unmarked; --=no data; B=bred during that season; NB=did not breed; cub, yrlg, 2-yr, 3-yr=female accompanied by cub, yearling, 2-year-old or 3-year-old young; cub/B=cubs lost prior to breeding season, subsequent breeding by female; yrlg/B, 2-yr/B, etc.=offspring weaned, then subsequent breeding by female.

family group was composed of a sow and 2-year-olds, a fact indicative of a 3-year reproductive interval (weaning of offspring as 2-year-olds); however, during 1978, of six females with yearlings, five accompanied their 2-year-old offspring through the following summer; thus, these five females will display a minimum reproductive interval of 4 years. A similar pattern indicative of a 4-year, or greater, reproductive interval was observed during 1979. For these reasons, the projected annual changes in reproductive status of adult females were calculated, based on actual observations of reproductive histories. The following assumptions were made: 1) of those which had bred or were capable of breeding, 76 percent conceived and were accompanied by cubs the following summer; 15 percent conceived, produced cubs, lost them through mortality and bred the following summer; and 9 percent bred, were not accompanied by cubs the following summer and then bred; 2) of the females with cubs, 95 percent were accompanied by yearlings the following summer, and 5 percent weaned or lost their offspring and then bred; 3) 85 percent of those with yearlings were accompanied by 2-year-old offspring through the following summer, and 15 percent weaned them and bred; 4) 90 percent which kept their young as 2-year-olds weaned them during the following spring and then bred but 10 percent kept them as 3-year-olds; and 5) all of those females which did not wean their offspring as 3-year-olds did so the following spring.

Using these assumptions, it is possible to generate a mean length of reproductive interval for the population. Starting with a theoretical population of 100 adult females for each possible combination of reproductive situations which could result in a cycle of a given length, the proportion of those females with a cycle of that length can be calculated. For example, the number of cycles 4 years in length included the total of those females which would have: 1) bred but did not produce cubs and so bred again the first year; bred unsuccessfully again the second year; bred, then produced cubs and kept them through the third year; and weaned yearling offspring and bred the fourth year; 2) bred 2 years until cubs were produced and kept throughout the breeding season, accompanied through the year as yearlings and then weaned 2-year-old offspring and bred; and 3) bred and produced cubs the following season during the first year, kept the offspring through the summer during the second (yearling) and third (2-year-old) years and then weaned them and bred when the offspring were 3-year-olds. Using this method, 0.35 individuals would have a reproductive interval of 7 years; 4.65, 6 years; 20.02, 5 years; 58.05, 4 years; 12.60, 3 years; and 7.40, 2 years for a mean calculated reproductive interval of 4.03 years.

It must be emphasized that without data collected over a longer period of time, a more accurate expression of the reproductive intervals is not possible. However, in order to better compare the reproductive biology of grizzly bears in the western Brooks Range with those in other regions and to assess their population status, extrapolation of the data collected is necessary.

A mean litter size of 2.03 was determined from 67 offspring of 22 marked females and 10 unmarked identifiable females. This included three marked females each of which had two litters during the study period, but did not include one female accompanied by young of two different ages, a situation which presumably was the result of adoption. Litter size ranged from 1 to 3 per female; at the first observations of family groups, 23 females were accompanied by 30 cubs, 8 females were accompanied by 18 yearlings, and 1 female each was accompanied by two 2-year-olds and two 4-year-olds, respectively. Initial litter size of females accompanied by yearlings, 2-year-olds, and 3-year-olds may have been larger due to the increased possibility of mortality. However, since litter size of females accompanied by yearlings was greater than those with cubs, all litters were combined in litter size calculations.

The mean litter size of 2.03 found in the western Brooks Range was larger than those found in other studies in northern and Interior Alaska or the Yukon Territory. In those areas, litter size ranged from 1.60 to 1.83 (Reynolds 1974, 1976; Curatolo and Moore 1975; Pearson 1975, 1976; Dean 1976). In coastal Alaska, litter sizes ranged from 2.36 to 2.50 (Troyer and Hensel 1964; Glenn et al. 1976). These variations are probably reflections of the availability and nutritional quality of food which grizzlies may secure in the different regions.

The reproductive rate of a population is a measure of the potential of a population for growth and is expressed as the number of cubs produced per adult female per year (Craighead et al. 1976). Reproductive rate may also be expressed as the potential production of cubs during the reproductive life of an adult female. Table 4 compares the reproductive rates and potential production of cubs for four populations of brown or grizzly bears. The grizzly bear population in the western Brooks Range had a higher reproductive rate than the declining population in the eastern Brooks Range but not as high as populations in Yellowstone Park or the Alaska Peninsula. Potential production of cubs during the lifetime of an adult female was similar in the western Brooks Range and the Alaska Peninsula, primarily reflecting longer reproductive longevity of bears in northern Alaska. This difference may be due to a high level of hunting pressure on the peninsula which results in lower chances of survival to maximum potential age.

Mortality

Twenty-one mortalities were recorded in the study area, including 11 cubs, 2 cubs or yearlings, 7, 1- to 3-year-olds, and 1 adult. Three mortalities occurred between one summer and the next so it could not be determined if two young died as cubs or yearlings or if another was a yearling or 2-year-old. Mortality in bear populations usually results from a number of factors including inter- and intraspecific contacts, disease, accidents, and those which were human-induced. The causes of most mortality in this study could not be identified conclusively. One yearling, No. 1107, was very small (3 kg or 6.5 lb.) when captured as a cub, but survived through the winter and died in late May 1978, possibly

Table 4. Reproductive rates of grizzly bear populations.

Area	Mean Age at 1st Breeding to Maximum Age of Breeding	Potential Reproductive Life ÷ Reproductive Interval		Litter Size		Potential Production of Cubs	$\bar{x}$ Reproductive Rate (No. cubs/ female/year)
Yellowstone Park (Craighead et al. 1976)	6.3 - 25.5	$\frac{19.2 \text{ years}}{3.40}$	x	2.24	=	12.65	0.658
Alaska Peninsula (Glenn et al. 1976)*	6.3 - 22.5**	$\frac{16.2 \text{ years}}{3.77}$	x	2.50	=	10.74	0.664
Eastern Brooks Range (Reynolds 1975)*	10.1 - 24.5	$\frac{14.4 \text{ years}}{4.24}$	x	1.78	=	6.42	0.420
Western Brooks Range (this study)	8.4 - 26.5	$\frac{18.1 \text{ years}}{4.03}$	x	2.03	=	9.11	0.503

* My analysis of data presented by others.

** Data presented by these researchers designated greatest longevity of females as age 18.5; since that time new records have been observed (J. Faro, pers. comm.).

killed by its siblings. A wolf (*Canis lupus*) was seen harassing an unmarked female with three cubs near Iligluruk Creek (D. James, pers. comm.); a female of the same description with only two cubs was later seen in the same vicinity, and it was assumed that the initial encounter may have resulted in the death of one of the cubs. Two-year-old male No. 1162 died approximately 10 days after he was captured; his death may have been study-related but evidence was not conclusive.

Adult males probably caused most of the mortality observed in this study. A single large adult male, No. 1099, killed at least two other bears: No. 1101, a 2-year-old male, and an unmarked cub of female No. 1104. In addition, there is some evidence that he may have killed adult female No. 1106 and her two 2-year-old offspring, Nos. 1108 and 1109. On 4 May 1979, the freshly killed carcass of No. 1106 was located 1 mile northwest of her den site. The cause of death was wounds received on about 3 May 1979 in the mid-back and chest from a much larger, presumably male, grizzly; search of the area for her two offspring, Nos. 1108 and 1109 was unsuccessful then and during the summer, so they were presumed killed as well. The site of the death of No. 1106 was close to the direct path between the winter den of No. 1099 (29 mi SE) and his location (5 mi N) on 4 May 1979, the day after No. 1106 was killed. Moreover, No. 1099 was the only large, adult male which included the kill site within his home range at that season of the year.

No other direct evidence of adult male-caused mortality was recorded but another large male, No. 1082, was observed confronting, or stalking, female No. 1038 and her three offspring near the Kokolik River. This confrontation lasted more than 30 minutes, with the male actively pursuing the female which snarled as she retreated. Intraspecific mortality caused by adult males has been documented in the past in Alaska (Troyer and Hensel 1962; Reynolds 1974, 1976; Glenn et al. 1976) and in Canada (Mundy and Flook 1973; Pearson 1975, 1976).

Thirteen mortalities were not directly observed but were recorded after offspring which had been observed in a family group were not subsequently observed. In 1979 these included nine cubs, which comprised the entire litters of five females. Their disappearances occurred between early May and late June when cubs were smallest and least able to escape; of the five females which lost their litters, three were seen during the breeding season (from late May to early June) and were judged to be in estrous condition.

Indirect evidence of mortality is also indicated by numerical differences between cohorts in the age structure of the population (Table 1). The lowest apparent survival rate occurs during ages 3.5 and 4.5 years or after weaning occurs, but the sample size is too small to make a definitive judgment. This is a time when animals are beginning to seek home ranges of their own without the protective influence of their mothers. Another explanation for the low representation of the 1974 and 1975 cohorts, which were the 3.5- and 4.5-year-old cohorts of the 1978 population, could be that they suffered high mortality rates after emerging from the maternal den, much the same as the 1979 cohort did.

Factors Influencing Population Density and Reproductive Biology

Comparison of the grizzly bear population in the eastern Brooks Range (Reynolds 1974, 1976; Curatolo and Moore 1975) with that in this study area indicates that both population density and productivity are much greater in the western Brooks Range. This may be a localized phenomenon due to the proximity of the traditional caribou calving grounds of the Western Arctic caribou herd to the grizzly bear intensive study area. This proximity in turn increases the availability of caribou as a source of carrion and prey which may allow an increase in the productivity and density of the grizzly bear population.

These caribou may provide a protein source unavailable in the same quantities to other grizzly bear populations whose range does not overlap caribou calving grounds. Caribou may be a particularly important segment of the grizzly bears' diet because they are available during a time when those portions of vegetation upon which bears feed are of poor nutritive quality; overwintering roots, tubers, and bulbs begin to mobilize their nutrient supply into flower and leaf production during early summer, and most above-ground vegetation favored by bears is just beginning to grow (J. Bryant, pers. comm.). Caribou are available to bears as an abundant source of protein at a time when energy demands by bears are also high because of activity and movement associated with breeding. Because grizzly bear population size and reproductive capacity are probably closely related to food availability, relatively high density and reproductive capacity of bears in an area of high protein availability would be expected.

Although this population appears to be relatively dense and productive for an Arctic population, the apparent low rates of survival for some cohorts may serve as a dampening factor on population growth. It is unlikely that further improvements in length of reproductive cycle, length of reproductive life, or litter size would occur even if food supply were to increase. However, changes in the present rates of survival would in turn affect population maintenance or growth. The two critical periods of survival are during the first month after cubs leave the maternal winter den and for the first 1-2 years following weaning.

Movement and Home Range

During the study period, movements and/or home range size were determined from 1,044 sightings of 83 of the 88 bears which had been immobilized and fitted with visual markers or radio collars; five bears were not seen after tagging. The majority of the resightings were of radio-collared bears, but some extreme movements were determined by resighting marked bears. The maximum distance traveled by bears of different sex and age categories was as follows: adult males, 163 km

(101 mi); subadult males, 77 km (48 mi); breeding females, 55 km (34 mi); females with young, 38 km (24 mi); and subadult females, 18 km (11 mi).

Although grizzlies may move long distances during short periods of time, the average daily movements observed were relatively small. The extent of average daily movement for bears, in order of decreasing distance, was: breeding males, breeding females, females with offspring, and subadult males or females (Table 5). The magnitude of subadult individual movements was probably underestimated because the radio-collared individuals did not travel widely; other data indicate some subadult individuals, especially males, travel extensively prior to establishing a center of activity.

Because bears often spend several days in one area, travel to another area of use, and then return to the area previously used, the magnitude of mean daily movement was related to length of time between sightings. Of 97 instances in which observations were separated from previous observations of the same bear by 2 days or less, the average distance traveled was 5.0 km (3.1 mi); males moved an average of 6.0 km (3.8 mi) in 44 observations of 6 bears, and females moved an average of 4.0 km (2.5 mi) in 53 observations of 11 bears.

Movement outside the center of activity for individual bears did not usually occur, however, such movement during the breeding season or in search of food or denning sites was recorded. Although it was generally assumed that bears may move long distances to reach the core caribou calving area of the Western Arctic Herd, our data did not support this. It is more probable that bears whose home ranges overlap calving areas or migratory corridors concentrate their feeding in these areas during the calving and post-calving migratory periods. Similar observations have been reported for grizzly bear/caribou movements in northern Yukon Territory (Pearson 1976). In 1978 two large adult males were observed following groups of migrating caribou cows and calves during post-calving migration 19.3 and 22.5 km (12 and 14 mi) west of their 1977 home ranges. However, the extent of range increases for these males was not significant, especially considering the extent of movement beyond their 1977 home ranges at other times during 1978.

For comparative purposes, home ranges were calculated by two methods from 1977-1978 observations: the modified exclusive boundary strip (Berns and Hensel 1972, Curatolo and Moore 1975, Reynolds 1976) and the minimum area or minimum home range polygon (Craighead and Craighead 1972; Pearson 1975, 1976; Craighead 1976). The modified exclusive boundary strip method is based on the approximate size of daily movements and use of the method does not include large expanses of area in which no observations or assumed movements would have occurred (Fig. 1). This method was used in the eastern Brooks Range (Curatolo and Moore 1975, Reynolds 1976) to delineate the home ranges of bears

Table 5. Daily and maximum movements recorded for 26 radio-collared grizzly bears* in the western Brooks Range, 1977-79.

Reproductive Status	Range of $\bar{x}$ Distance Traveled		Range of Individual Observations of Distance Traveled		Range of Maximum Distances Between Sightings	
	km/day	(mi/day)	km/day	(mi/day)	km	mi
Adult males	1.3-5.1	(0.8-3.2)	0 -38.6	(0-24.0)	22.5-81.3	(14.0-50.5)
Subadult males	0.3-2.7	(0.2-1.7)	0.2- 6.6	(0.1-4.1)	10.1-17.9	(6.9-11.1)
Breeding females	1.0-3.5	(0.6-2.2)	0.2-20.1	(0.1-12.5)	13.7-47.6	(8.5-29.6)
Females/cubs	1.0-1.8	(0.6-1.1)	0.2- 4.7	(0.1-2.9)	16.1-33.8	(10.0-21.0)
Females/yearlings	0.5-2.4	(0.3-1.5)	0 - 9.7	(0-6.0)	7.2-20.4	(4.5-18.9)
Females/2,3&4-year-olds	0.5-3.5	(0.3-2.2)	0 - 5.1	(0-5.6)	17.4-38.0	(10.8-23.6)
Subadult females	1.0-3.7	(0.6-2.3)	0.2-13.7	(0.1-8.5)	12.9-17.9	(8.0-11.1)

* Movements were recorded for 26 individuals; 20 of these were calculated in 2 years and 6 in 3 years. In such cases, figures for each year are included in the calculation of mean figures.

which traveled primarily along river valleys and did not utilize the expanses of mountainous country which separated adjacent river valleys. Home ranges were calculated by this method so ranges of grizzlies in the present study in the western Brooks Range can be compared with those in the eastern Brooks Range (Table 6). Using the modified exclusive boundary strip method, the home ranges of seven breeding male grizzlies in the western Brooks Range had a mean area of 510 km^2 (197 mi^2) compared with a mean home range of 702 km^2 (271 mi^2) for five male grizzlies in the eastern Brooks Range. Sixteen females in the western Brooks Range had home ranges with a mean area of 269 km^2 (104 mi^2) compared with the mean home range area of 230 km^2 (89 mi^2) for eight females in the eastern Brooks Range. The larger size of male home ranges in this study compared with those found in eastern Brooks Range animals may reflect differences in topography.

Minimum home range polygons (Craighead and Craighead 1972; Pearson 1975, 1976; Craighead 1976) were calculated for 26 grizzlies during 1977-1979; 7 of these were calculated for 3 years, 12 for 2 years, and 7 for 1 year (Table 6). These home ranges were calculated by plotting observations of radio-collared bears on mylar overlays of topographic maps, connecting the peripheral location sites, and calculating the area enclosed for each year. Fig. 2 illustrates movement of adult female No. 1097 during 1977 from capture to denning and construction of her home range; Figs. 3 and 4 illustrate movement during 1978 and 1979, respectively, from emergence from the den in spring to denning the next fall; and Fig. 5 shows the juxtaposition of the three home ranges and construction of a single home range for the 3-year period.

Because most other studies of grizzly bear movements and home ranges have utilized the minimum area polygon method to determine home range size, that method was used in this study for most data analysis. Home ranges reported here are considerably larger than those calculated for bears in other areas (Table 7). Differences in home range size between bears on Alaska's North Slope and other areas of North America likely reflect the relatively low quality and short period of availability of forage on the north slope of the Brooks Range.

Home ranges for 17 individuals were calculated both in 1977 and 1978; seven of the 17 were determined again in 1979. Although the areas of greatest use within a home range did not change from year to year, the areas on the periphery of home ranges were sometimes used extensively in one year and not the next. Because of these changes the size of home ranges varied from year to year and the home ranges calculated for the entire study period were greater than for any one year. There was no pattern of general increase or decrease in home range size between the 3 years.

Table 8 compares the home ranges of bears of different reproductive status. In general, the reproductive status of bears in order of decreasing home range size was: breeding males, breeding females, subadult females, and females with offspring (accurate home range was calculated for only one subadult male).

Table 6. Home ranges of 26 grizzlies in the western Brooks Range as determined by the modified exclusive boundary strip and minimum area methods, 1977-1979.

Bear No.	Modified Exclusive Boundary in Km^2 (Mi^2) 1977	1978	1979	Minimum Area in Km^2 (Mi^2) 1977	1978	1979	Total
Adult Males							
1082	443(171)	326(126)	420(162)	603(233)	231 (89)	508(196)	924(357)
1083	466(180)	490(189)		583(225)	663(256)		1005(388)
1088	549(212)			1776(686)			1786(686)
1091	389(150)	326(126)		637(246)	308(119)		746(288)
1096	464(179)	606(234)		723(279)	730(282)		1077(416)
1099	691(267)	862(333)	583(225)	1399(540)	1597(607)[a]	1494(577)[a]	4167(1609)
					837(323)[b]	899(347)[b]	1927(744)
1103	549(212)			961(371)			961(371)
Subadult Males							
1164			233 (90)			142(55)	142 (55)
Subadult Females							
1087			163 (63)			104(40)	104 (40)
1102		210 (81)			122 (47)		122 (47)
Adult Females							
1085	376(145)	420(162)	280(108)	546(211)	534(206)	186 (72)	873(337)
1086	290(112)	303(117)	256 (99)	223 (86)	145 (56)	192 (74)	357(138)
1090	186 (72)	256 (99)		88 (34)	135 (52)		158 (61)
1092	210 (81)	233 (90)		104 (40)	130 (50)		194 (75)
1097	350(135)	303(117)	303(117)	360(139)	215 (83)	300(116)	583(225)
1100	326(126)	373(144)	130 (50)	267(103)	316(122)[a]	52 (20)[a]	694(268)[a]
					225 (87)[b]		464(179)[b]

Table 6. Continued.

Bear No.	Modified Exclusive Boundary in Km^2 (Mi^2)			Minimum Area in Km^2 (Mi^2)			
	1977	1978	1979	1977	1978	1979	Total
1104	316(122)	373(144)		363(140)	368(142)		539(208)
1105	186 (72)	396(143)	140 (54)	109 (42)	394(152)	98 (38)	412(159)
1106	430(166)	256 (99)		489(185)	194 (75)		477(184)
1110		210 (81)			93 (38)		93 (38)
1111	363(140)	303(117)		396(153)	223 (86)		461(178)
1121	223 (86)	163 (63)		192 (74)	98 (38)		236 (91)
1134	130 (50)	210 (81)		39 (15)	117 (45)[a]		122 (47)[a]
					49 (19)[b]		80 (31)[b]
1139		280(108)	303(117)		225 (87)	218 (84)	368(142)
1142		210 (81)			168 (65)		168 (65)
1145		246 (95)	186 (72)		194 (75)	88 (34)	233 (90)

[a] and [b] During a short period, three bears, Nos. 1099, 1100 and 1134, traveled from their summer range to a den site, a movement which greatly increased the size of the home range calculated by the minimum area method. Since this increase in home range did not reflect an increase in the potential habitat used, minimum area was calculated in two ways: one which includes the den site in calculation of home range ([a]) and one which excludes the den site ([b]).

Table 7. A comparison of home ranges for male and female grizzlies in North America calculated by the minimum area polygon method.

Area	Sex	No. in Sample	Mean Home Range Size km^2	(mi^2)
Yellowstone Park	males	6	161	(62)
(Craighead 1976)	females	14	73	(28)
Western Montana	males	3	513	(198)
(Rockwell et al.)	females	1	104	(140)
Southwestern Yukon	males	5	287	(111)
(Pearson 1975)	females	8	86	(33)
Northern Yukon	males	9	414	(160)
(Pearson 1976)	females	12	73	(28)
Northwestern Alaska	males	8	1350	(521)
(this study)	females	18	344	(133)

Table 8. Home ranges of grizzly bears grouped by reproductive status of individuals and calculated by the minimum area method (in km^2) for 1977-1979. Home ranges of individual bears calculated during more than 1 year are indicated by connection with dashed lines; ranges without dashed lines indicate home ranges determined in 1 year only.

Breeding Males	Nonbreeding Males	Nonbreeding Females	Breeding Females	Females w/Cubs	Females w/Yrlgs	Females w/2&4-Yr-Olds	Breeding Females[a]
603-----231-----508	142	267-------316-----52[b]		104-------130			
1399----1597----1494		316	546----534----186[b]	479-------194			
583-----663		88[c]	360----215----300	192--------98		194-------[c]	
637-----308		104	109----394-----98	225-------218		396------223[a]	
723-----730			223 192	98	223-------145------192[a]		
1776			194		39-------117		
961					88-------135		
Yearly							
Mean 872	142	194	290	220	133	197	
Range 231-1776		88-316	109-546	98-479	39-223	117-396	

[a] This category is included to illustrate variation in home range size of individual females as reproductive status changed; for purposes of calculation of mean, these figures are included in a previous column with the same heading.
[b] Because of the relatively low number of observations made for these bears in 1979, home ranges were probably underestimated; therefore, these figures were not included in calculations.
[c] In 1978 bear No. 1146 and her 2-year-old radio-collared offspring, No. 1145, traveled together and so were included in the Females w/2-year-old category; in 1979, No. 1145 was weaned and so her movements were included in the nonbreeding category.

After they were weaned, some young-age grizzlies maintained a home range within the range they had used when they accompanied their mothers; others used some portions of their maternal home range but also wandered outside of it. Siblings Nos. 1087 and 1164, offspring of No. 1086, were weaned as 3-year-olds and separated from each other but stayed within the portion of the area which was most heavily used by the family group during the previous 2 years (Fig. 6). In two other instances, recently weaned 3-year-olds stayed within the core area of their maternal home ranges during most of the summer but made brief forays to areas beyond the border of their previously observed home range. This indicates that dispersal from the home range that young-age bears used when under maternal care does not occur, in some instances, until the season after weaning.

Although grizzly bears may be aggressive toward other bears of the same sex during the breeding season, they do not maintain defended territories, and home ranges of bears overlap broadly (Figs. 7, 8, and 9). Factors responsible for size and shape differences in home ranges are not known, but the bears with the largest home ranges were males which traveled most widely during June and early July. This is a time when grizzly bear breeding and caribou calving occur. Bears with the smallest home ranges were females which spent the season in relatively steep areas in the Brooks Range foothills.

Habitat Use and Food Habits

Although home ranges of radio-collared bears were located in different sections of the study area, portions of almost every home range contained all delineated habitat types. In order to analyze habitat use by bears, Hechtel (Appendix III) devised the following breakdown of habitat types, based on the relatively simple classification made by Spetzman (1959) and the comprehensive divisions of Alaskan Arctic tundra by Murray and Batten (1977):

Fellfield-Barrens
Talus
Dryas - dwarf shrub
Dryas - step and stripe
Carex Bigelowii meadow
Tussock tundra
Betula tussock
Betula thicket
Wet sedge meadow
String bog
Riparian
Late snowbank community

Hechtel (Appendix III) followed radio-collared female No. 1086 with her two offspring during 1977-1979 to determine habitat use by the family group. His preliminary analysis of seasonal use patterns of habitat type was as follows:

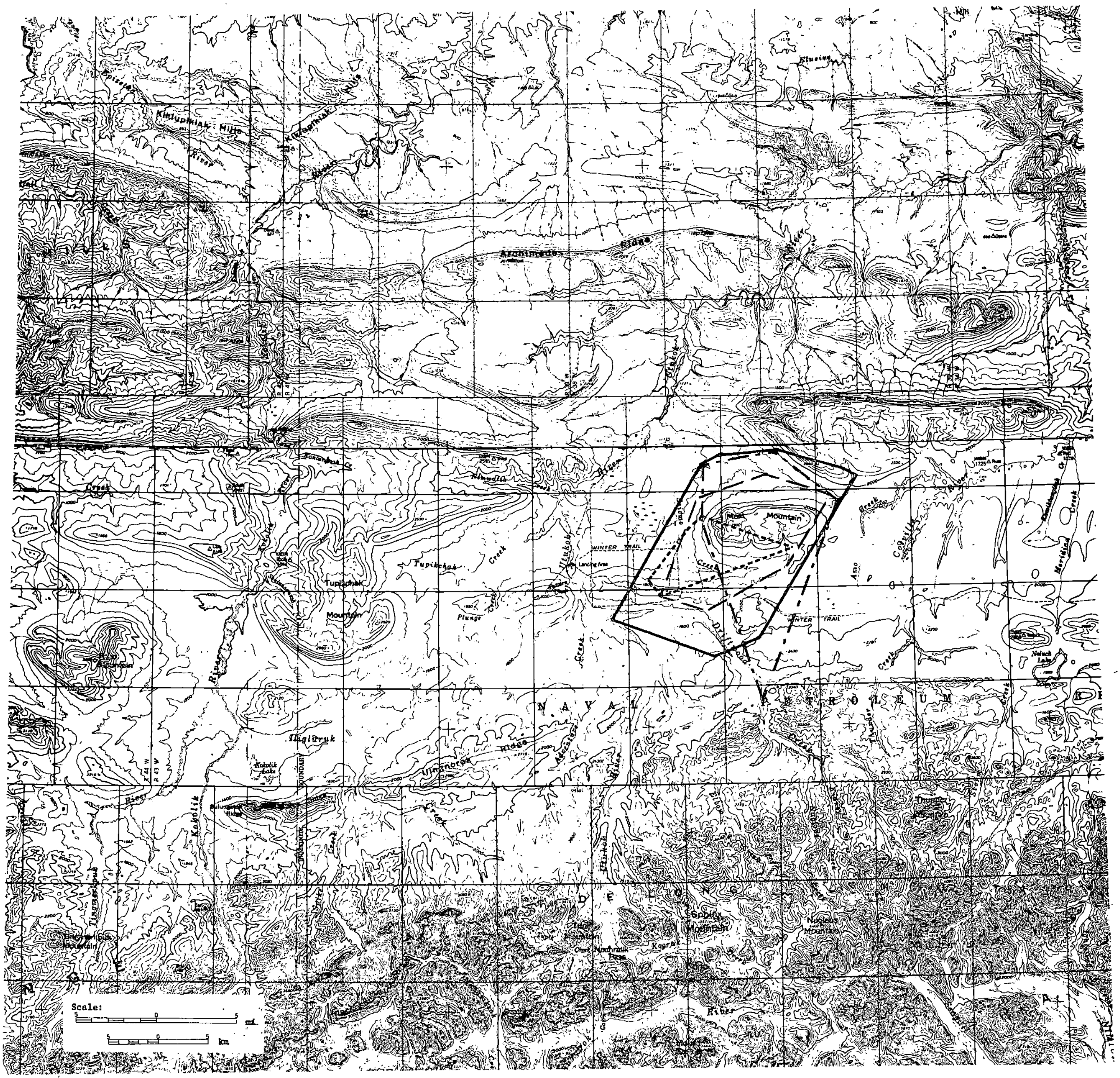

Fig. 6. The home range of a family group prior to weaning in 1977, 1978, and early spring 1979, and after weaning in 1979. The family group consisted of female No. 1086 and her two offspring, female No. 1087 and male No. 1164. Solid lines indicate home range of family group prior to weaning; skipped line, 1086 after weaning, including breeding; dotted line, 1087 after weaning; and dashed line 1164 after weaning.

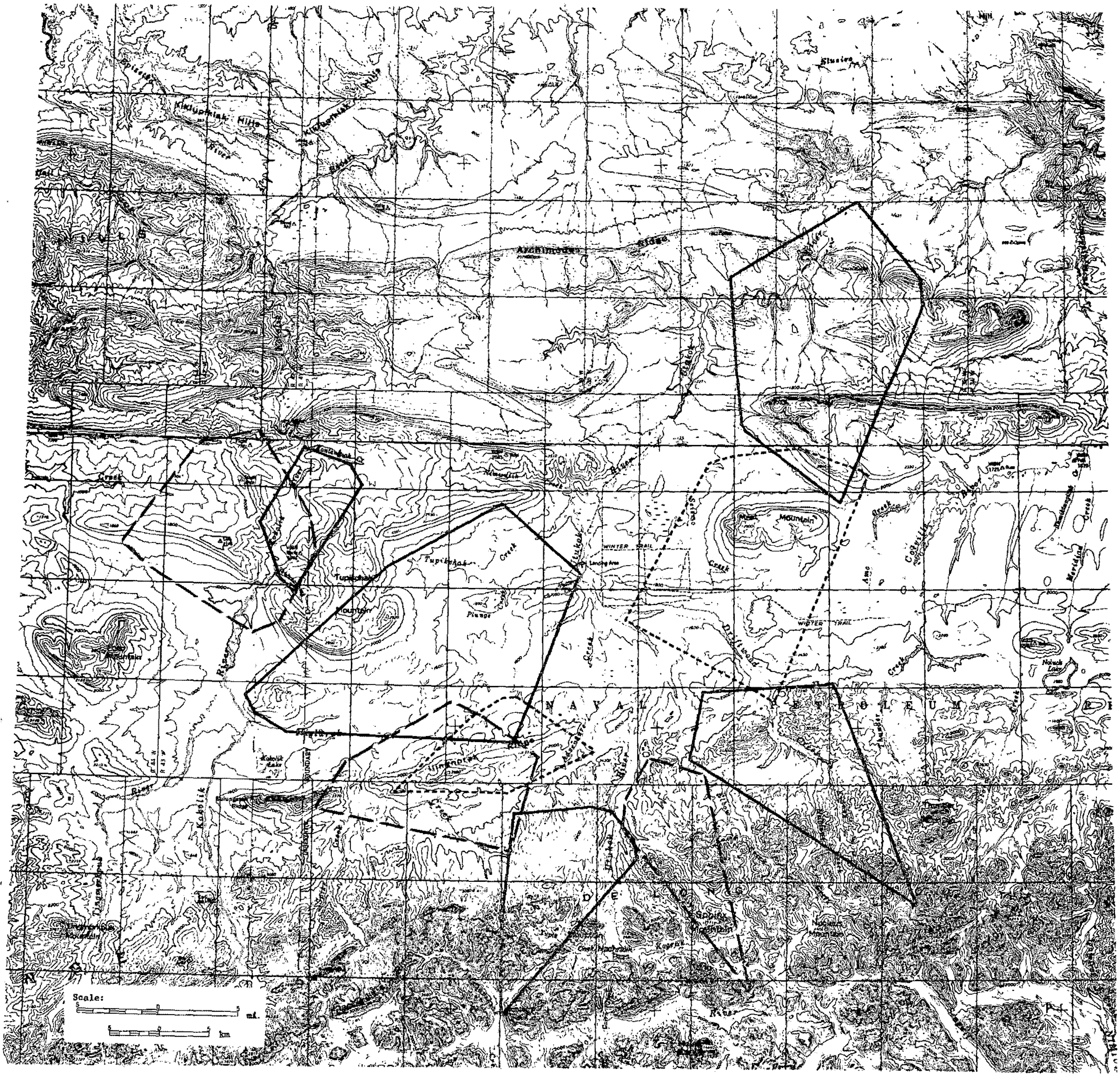

Fig. 7. The home ranges of 10 females accompanied by offspring in the study area.

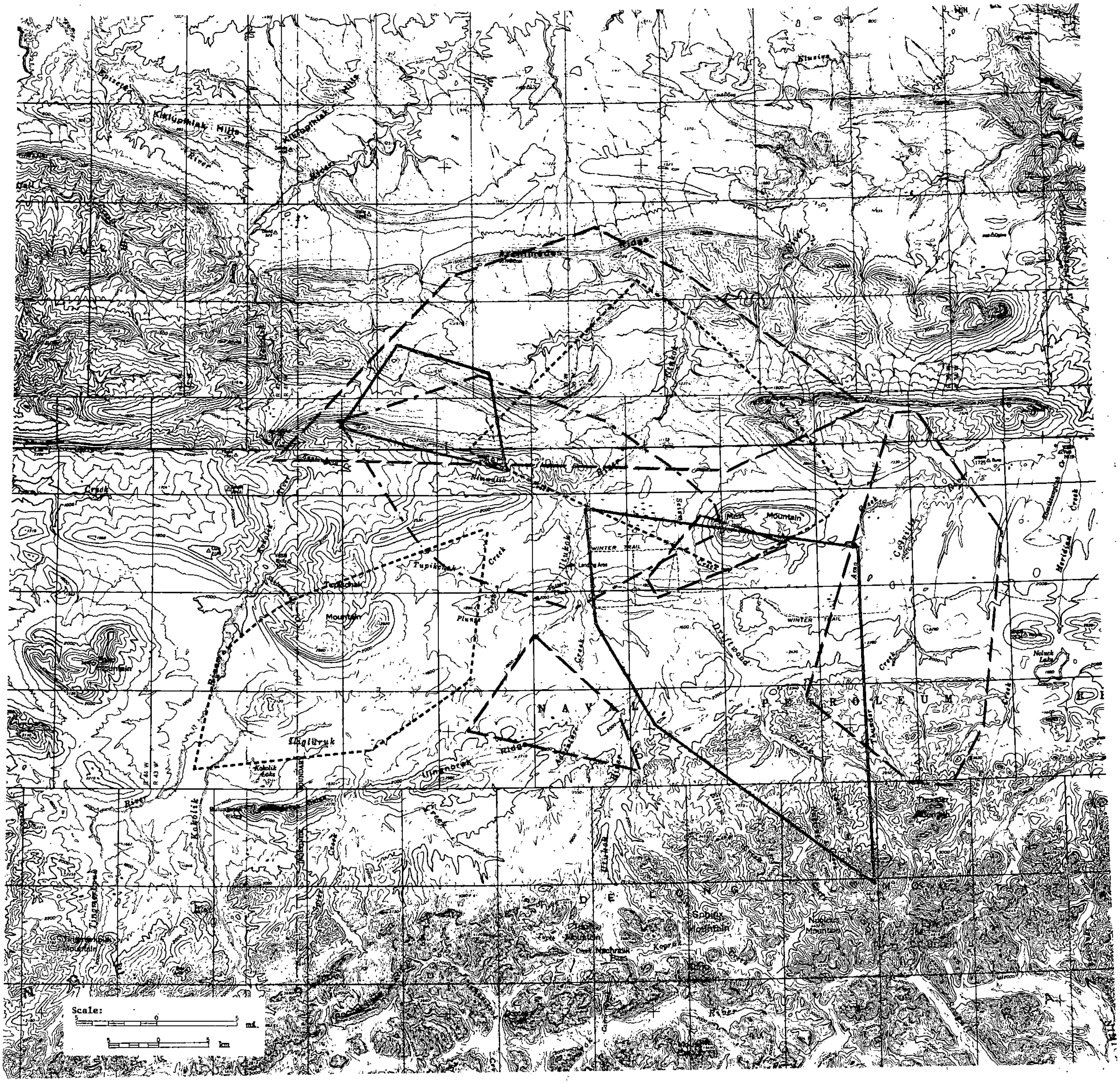

Fig. 8. The home ranges of nine females without offspring in the study area.

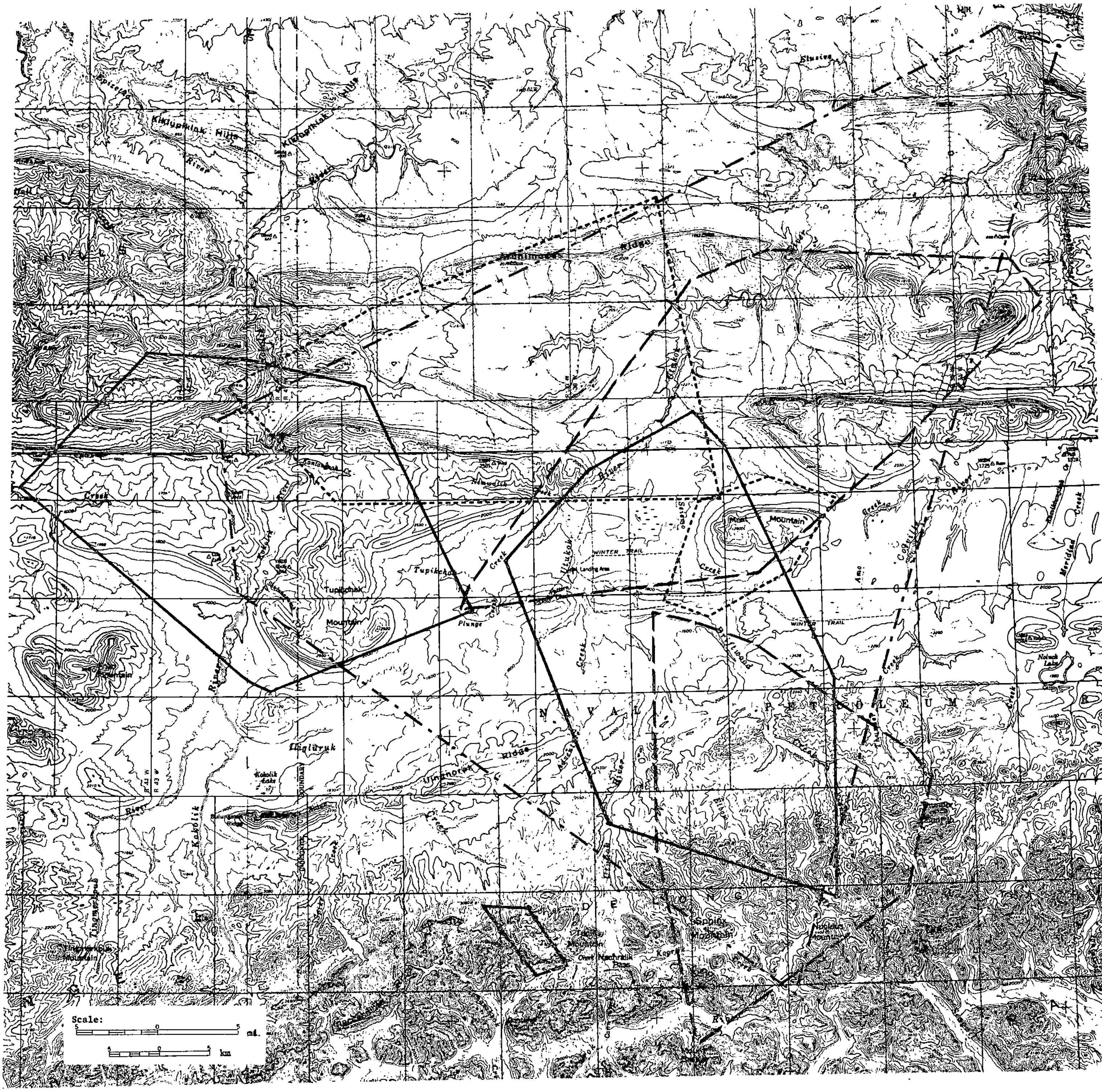

Fig. 9. The home ranges of eight males in the study area.

(Note: The largest home ranges are those of adult males; one 2.5-year-old male maintained a very small home range during July-August 1978 prior to loss of the radio collar; another 3.5-year-old male stayed within the maternal home range after weaning.)

Season	Main Habitat Types Used
Pre-growing through early growing season: May through early June	*Dryas* step and stripe; *Dryas* dwarf shrub; riparian
Growing season: early June through late July	Wet sedge meadow; late snowbank community; tussocks
Post-growing season: early August through denning in early October	Floodplain; *Dryas* step and stripe; *Dryas* dwarf shrub; *Betula* tussocks; string bogs

These observations, although determined for a single family group, probably are representative of most bears in the study area. In general, bears observed foraging in the study area used river courses and snow-free ridges and mountain slopes during spring (May to early June), vegetation along the small creeks or moist drainages from early June to late July, and the floodplains of large creeks and rivers as well as dry ridge areas or mountain slopes with ground squirrel (*Spermophilus parryii*) populations from early August until denning in October. In addition, during the breeding season, from late May through mid-July, bears were observed in all types of terrain, from tussock tundra to talus slopes.

As well as documenting habitat use by No. 1086 and her young, Hechtel (Appendix III) also determined their seasonal food habits by direct observation and from analysis of scats. The most important seasonal foods, based on amount of use, were:

Pre-growing season	Growing season	Post-growing season
Hedysarum alpinum-roots	grasses and sedges	*Hedysarum alpinum*-roots
Oxytropis borealis-roots	*Boykinia Richardsonii*-leaves, stems & flowers	*Arctostaphylos rubra*-berries
Arctostaphylos rubra-overwintered berries	*Equisetum arvense*-fruiting & vegetative stems	*Spermophilus parryii* ground squirrels

Although bears primarily consume plant foods, they are opportunistic feeders and eat caribou, ground squirrels, marmots (*Marmota caligata*), microtine rodents, and birds when available. Caribou may be an especially important food resource for bears because they represent a significantly higher total caloric yield than other foods, even though caribou are available to any one individual in relatively low numbers.

Denning

Because inclement weather and logistical problems precluded aerial tracking in October 1979, only one den was located. Therefore, with minor exceptions, data presented and discussed here represent 1977 and

1978 only. Forty-five newly excavated den sites were located on the study area during 1977-1979 (Table 9). Because of fall snow storms and inclement weather, the exact dates of denning were only determined for a few grizzlies; more often, dates only could be determined within a 2- to 6-day period. Weather patterns differed during the denning periods in 1977, 1978, and 1979, it is probable that timing and site selection reflected this difference. During 1977, when bears denned later, snow blanketed most of the study area in mid-September, and by 1 October snow cover in most of the area was about 25 cm (10 in). This was followed by two successive 9-day snow storms accompanied by 80-130 km/hr (50-80 mi/hr) winds beginning the first week in October. Bears began denning about 2 October and by 23 October all bears were in dens except one adult male which was seen 200 m (660 ft) from a newly excavated den. The mean dates of denning in 1977 were from 12 to 18 October.

In 1978 there was only a light cover of snow by late September; from 28 September to 2 October there was light snowfall accompanied by winds. Then a storm lasting from 4 to 10 October brought heavier snowfall; from 11 to 13 October only light snow fell sporadically and the temperature dropped to -29°C. Bears began denning by 29 September-3October; by 13 October 80 percent of the dens located were occupied. By 17 October only one adult male, No. 1096, had not found a den site and his tracks in the snow showed where a number of excavations had been attempted. Bears denned earlier in 1978 than they had in 1977: the mean range of denning dates in 1977 was from 12 to 18 October, in 1978 from 7 to 9 October.

In 1979 the first heavy snow storm occurred from 14 to 20 September, followed by unseasonally warm weather which lasted until early October. Beginning in early October temperatures dropped and sporadic snow storms continued through the rest of the month. A research crew at the Driftwood airstrip reported that no bear tracks were observed after 15 October, and presumably most bears were in dens by that date.

During 1977 and 1978 females denned earlier than males. In 1977 there was no difference in the timing of den construction between solitary females and those with offspring, but in 1978 solitary females denned an average of 6 days earlier than females with yearlings.

Like grizzlies in the eastern Brooks Range (Reynolds et al. 1976), bears in the study area selected, excavated, and occupied den sites within a 2- or 3-day period. On the other hand, grizzlies in Yellowstone Park (Craighead and Craighead 1972) constructed dens as much as a month prior to the time of final entry. This variation in timing of den construction is probably related to differences in soil characteristics. The den sites in the study contain soils which are coarse, well drained, and free of permafrost to a depth of at least 1.5 m. In these types of soils, excavations will collapse unless the top 10 cm layer of soil is frozen, a situation which usually occurs after the temperature drops to about -10°C for a week or more. Thus, den construction cannot begin until the top layer of soil freezes, providing structural support. This principle is also illustrated in the spring when, almost without exception, dens collapse as soon as the top layer of soil thaws.

Table 9. Denning characteristics of 29 grizzly bears in the western Brooks Range, 1977-1979.[a]

Bear No.	Reproductive Status	Den Elevation m(ft)	Den Exposure	Terrain	Date of Denning	Distance from 1977 Den km (mi)
1082	breeding male	300(1000)	S	creek bank	after 24 Oct 1977	
	breeding male	300(1000)	SSW	creek bank	4-8 Oct 1978	17.5 (10.9)
1085	breeding female	340(1100)	NE	creek bank	4-10 Oct 1977	
	breeding female	550(1800)	SW	butte slope	1-2 Oct 1978	14.6 (9.1)
1086	female with 2 yrlgs	730(2400)	NW	butte slope	9-10 Oct 1977	
	female with 2 2-yr-olds	730(2400)	SW	butte slope	5-10 Oct 1978	2.1 (1.3)
	breeding female	670(2200)	S	butte slope	prior 26 Oct 1979	4.7 (2.9)
1090	female with 3 yrlgs	910(3000)	N	mountain slope	9-14 Oct 1977	
	female with 3 2-yr-olds	910(3000)	S	mountain slope	4-10 Oct 1978	
1091	breeding male	980(3200)	NW	mountain slope	10 Oct-1 Nov 1977	
	breeding male	1100(3600)	W	mountain slope	4-10 Oct 1978	4.7 (2.9)
1092	female with 1 cub	730(2400)	SW	ridge slope	4-9 Oct 1977	
	(abandoned first den)	610(2000)	S	ridge slope	14 Oct 1977	2.9 (1.8)
1096	breeding male	300(1000)	WNW	river bluff	24 Oct 1977	
	breeding male	730(2400)	N	butte slope	about 18 Oct 1978	11.7 (7.3)
1097	breeding female	580(1900)	S	ridge slope	10-14 Oct 1977	
	breeding female	370(1200)	S	rolling tundra	1-2 Oct 1978	5.0 (3.1)
1099	breeding male	490(1600)	WSW	creek bank	14-23 Oct 1977	
	breeding male	790(2600)	E	creek bank	4-12 Oct 1978	45.7 (28.4)
1100	nonbreeding young female	430(1400)	S	riverbank	4-9 Oct 1977	
	(abandoned den 10-14 Oct, new site not located)					
	breeding female	1280(4200)	NE	mountain slope	4-10 Oct 1978	
1102	nonbreeding young female	580(1900)	N	ridge slope	8-9 Oct 1978	
1103	breeding male	520(1700)	SW	ridge slope	14-23 Oct 1977	
1104	breeding female	730(2400)	SE	ridge slope	10-14 Oct 1977	
	breeding female	610(2000)	N	ridge slope	1-2 Oct 1978	3.9 (2.4)
1105	breeding female	790(2600)	SE	ridge slope	13 Oct-1 Nov 1977	
	breeding female	730(2400)	NE	ridge slope	28-30 Sept 1978	2.1 (1.3)
1106	female with 3 cubs	490(1600)	S	rolling tundra	13-23 Oct 1977	
	female with 2 yrlgs	580(1900)	S	ridge slope	10 Oct 1978	5.1 (3.2)

Table 9. Continued.

Bear No.	Reproductive Status	Den Elevation m(ft)	Den Exposure	Terrain	Date of Denning	Distance from 1977 Den km (mi)
1110	female with 2 cubs	610(2000)	S	ridge slope	12 Oct 1978	
1111	female with 2 4-yr-olds	730(2400)	ESE	ridge slope	5-9 Oct 1977	
	breeding female	910(3000)	N	rolling hills	1-2 Oct 1978	35.4 (22.0)
1121	female with 2 cubs	610(2000)	S	ridge slope	13-24 Oct 1977	
1134	female with 3 yrlgs	850(2800)	SSE	ridge slope	2-5 Oct 1977	
	female with 2 2-yr-olds	1040(3400)	SE	mountain slope	3 Oct 1978	16.1 (10.0)
1139	female with 2 cubs	730(2400)	N	butte slope	12 Oct 1978	
1145	2-yr-old female with mother	1200(3900)	NE	mountain slope	5-10 Oct 1978	
UM[b]	single	670(2200)	N	butte slope	14 Oct 1978	
UNK[b]		270 (900)	N	rolling hills	10-13 Oct 1978	
UNK[b]		460(1500)	SE	ridge slope	1-2 Oct 1978	
M[b]	single	550(1800)	NE	ridge slope	10 Oct 1978	
UM[b]	female with 2 2-yr-olds	610(2000)	S	ridge slope	16 Oct 1978	
UNK[b]		550(1800)	NE	ridge slope	10-16 Oct 1978	
UNK[b]		460(1500)	N	ridge slope	10-16 Oct 1978	
UNK[b]	single	550(1800)	SW	ridge slope	16 Oct 1978	

[a] Only the location of one den, that of No. 1086, was confirmed during 1979; others will not be located until February 1980.

[b] Bear designations: UM=unmarked; UNK=unknown if marked or unmarked; M=marked but colors of individual markers not determined.

Bears denned in a variety of terrain ranging from creek banks at low elevations to mountain slopes near the crest of the Brooks Range (Fig. 10). No special denning areas or concentration sites were found, and dens were distributed throughout the study area, usually well within the individual bear's home range. However, in 1978 four radio-collared bears denned from 16.1 km (10.0 mi) to 43.8 km (27.2 mi) outside of their spring, summer, and fall ranges; in addition, three bears which had presumably moved from their home ranges to den were not located after intensive searches. This type of pattern, in which the den site is separated from the rest of the home range by a migratory corridor, has been previously described in Wyoming by Craighead (1976). In 1977 dens of 17 radio-collared bears were found within their home ranges, but the dens of three radio-collared bears were not found after intensive search and these bears may have left their home ranges to den. Similarly, in the eastern Brooks Range, Reynolds et al. (1976) found that, although all radio-collared bears denned within their seasonal home ranges, there was evidence that a few visual-collared bears left their seasonal home ranges to den.

Elevations at den sites ranged from 270 to 1,280 m (900 to 4,200 ft). The mean elevation of male bear den sites was 520 m (1,700 ft) in 1977 and 590 m (1,920 ft) in 1978. Dens of females were found at a mean elevation of 710 m (2,330 ft) in 1977, 760 m (2,500 ft) in 1978, and one at 670 m (2,200 ft) in 1979. The mean elevation for all 45 bear dens located in 1977 and 1978 was 661 m (2,270 ft), compared with a mean elevation of 975 m (3,200 ft) for grizzly bear dens found in the eastern Brooks Range (Reynolds et al. 1976). This difference probably reflected the fact that the eastern Brooks Range study area was located in higher, more mountainous terrain than the present study area.

The 45 den sites were located on all exposures. There were differences between 1977 when 72 percent of dens (13 of 18) had a generally southern exposure from ESE to WSW and 1978 when 38 percent (10 of 26) faced generally south. Weather, especially wind direction and snow deposition, probably was important in den site selection. With no observed exception, den sites were located in areas of snowdrift deposition. Although the strong winter winds usually blow from the northeast or the northwest in the study area, local topography may cause wind eddies that allow snow deposition facing the general direction of prevalent winds. The selection of den sites in areas of high snow deposition was especially noticeable during spring 1978. Even though snow had melted from most areas in the study area, sites that bears had chosen for dens during fall 1977 were still overlaid by snowdrifts. The depth of permafrost which influenced the exposures chosen by bears in the eastern Brooks Range (Reynolds et al. 1976) was not important in this area, possibly due to differences in soil types. Another factor which may be responsible for north- or south-facing den exposures is that the topographic character of the foothill area is dominated by a series of east-west running ridges which

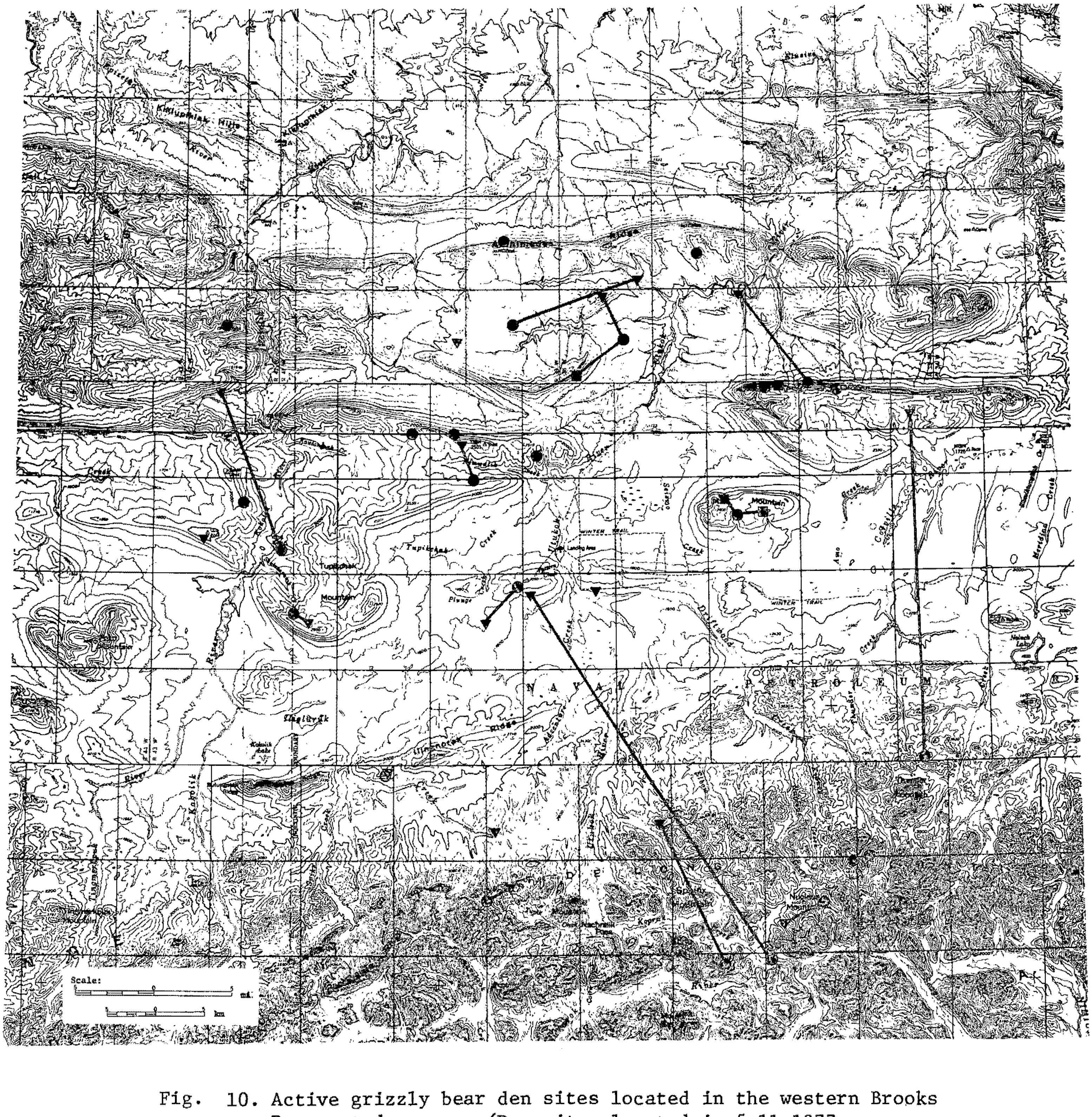

Fig. 10. Active grizzly bear den sites located in the western Brooks Range study area. (Den sites located in fall 1977 are designated by solid triangles, in 1978 by solid circles, and in 1979 by solid squares. Den sites connected by a line indicate dens used in different years by the same individual grizzly.)

have north and south exposures, thus, the occurrence of north or south exposures on the study area is probably highest.

Den sites excavated by individual bears in 1978 were separated by distances of 2.1 to 45.7 km (1.3 to 28.4 mi) from those dug by the same bears in 1977 (Table 9, Fig. 10). There does not appear to be a pattern of selection for similar types of terrain, exposure, or elevation by individuals from year to year. For example, in 1977 female No. 1085 denned on a northeast-facing creek bank of 340 m (1,110 ft) elevation, but in 1978 selected a site 14.6 km (9.1 mi) distant on a 550 m (1,800 ft) southwest-facing butte slope.

Three females abandoned their dens during winter 1977-1978. One of these, No. 1100, moved within 2 to 6 days after the den was excavated, but the new den site was not located. The second female, No. 1092, and her cub moved their den from the southern edge of their home range 12.4 km (7.7 mi) northwest to the center of their range. When den sites were checked in March, it was apparent that she had recently emerged from her relocated den and excavated 5-10 locations on the same hillside. The third female, No. 1105, had bred the previous summer but did not produce viable offspring in 1978. Examination of her den site in June 1978 revealed that she had abandoned her den during the winter after the depth of a snowdrift below the den site had reached 2 m (6.5 ft), had moved 100 m (330 ft), and then dug through the snowdrift to reach mineral soil. This den was poorly constructed and consisted only of a shallow excavation into the soil.

The causes of abandonment of dens were not known. The only potential source of human disturbance at the den sites was that of aircraft used in the study, but that was unlikely since by fall 1977 most of the bears were well habituated to the sound of aircraft.

Impact of Human Disturbance

Although human disturbance associated with gas or oil development may occur throughout the year, disturbance during the winter when grizzlies undergo long periods of winter dormancy would likely have the most serious effects. During late spring, summer, and early fall, bears are mobile and can usually escape sources of disturbance, but, during the period of winter denning, disturbance which was serious enough to cause bears to leave dens could result in poor physical condition or death. Also, since female grizzlies give birth in winter dens, disturbance could cause abandonment of dens, resulting in the death of young exposed to winter temperatures.

The sites of winter dens for 16 radio-collared grizzly bears were located in October 1977. In late February 1978 the Bureau of Land Management (BLM) provided the Alaska Department of Fish and Game (ADF&G) with the proposed locations of seismic exploration lines for oil and gas deposits in NPR-A. Nine of 16 dens which were located by radio-tracking were in the vicinity of seismic lines and three were within 1.6 km (1 mi). On-the-ground observations were made cooperatively by BLM and ADF&G in February and March 1978 to determine the effect of seismic detonations on two of the denning bears closest to seismic lines. Neither of the bears observed abandoned den sites but radio signal amplitude from the radio collars was erratic immediately after seismic explosions, indicating that some movement occurred within the dens (P. Reynolds, pers. comm.). One of these dens contained a female with three yearlings, all of which survived until emergence from the den (one died shortly after emergence from the den but the death was probably attributable to other factors). The other den contained an old female which bred in 1977 but did not emerge from the den with cubs in 1978. The latter bear was especially sensitive to disturbance by aircraft in 1977.

The results of these observations and aerial observations of other den sites near seismic lines indicate that no bears abandoned dens because of seismic explosions, however, bears were disturbed enough to shift their position inside the dens. Although such disturbance would not be detrimental to the majority of bears, agitation and disturbance of females with newborn cubs could result in the death of young; the possibility is not likely, but it could occur, especially with females which are very sensitive to disturbance.

The greatest potential human impact on maintenance of grizzly bear populations is that of wide-scale development and human habitation. Because grizzlies travel widely and have large home ranges, maintenance of enclaves of intact habitat is important; these should be at least as extensive as the 5,200 km^2 (2,000 mi^2) study area.

RECOMMENDATIONS

Although this study resulted in determining both baseline information important to understanding grizzly bear populations in northwestern Alaska and potential impacts that human disturbance may have on grizzly populations in the Arctic, additional information is needed. A technique for comparing the known density of bears in the study area with densities throughout the Brooks Range should be devised and tested. Observation of marked bears should be continued to improve the accuracy, or allow calculation of, longer-term population productivity, survival rates of young-age and mature grizzlies, and changes in habitat use and home range size. The effect of grizzly bear predation on Western Arctic Herd caribou, and the effect of the availability of caribou prey or carrion on grizzly bear productivity may be important and should be addressed in further studies.

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Appendix I. Sex, age, weights, and measurements[1] of grizzly bears captured in northwestern Alaska, 1977-1979.

Bear	Date	Sex	Age Cem[2] (yrs)	Measured Weight	Total Length	Shoulder Height	Hind Foot	Neck	Girth	Body Length	Head Width	Head Length	Left Upper Canine[3]	Left Lower Canine
1081	5/24/77	M	5.5	79	170	110	28	52	95	95	--	--	3.5	3.2
	9/17/79	M	7.5	195	191	123	29	78	--	102	21.7	37.0	2.7	3.0
1082	5/25/77	M	13.5	168	200	126	32	79	129	117	25.3	39.1	4.2	3.4
	6/13/77	M	13.5	166	--	--	--	--	--	--	--	--	--	--
	6/25/77	M	13.5	172	--	--	--	--	--	--	--	--	--	--
	6/27/78	M	14.5	193	202	128	35	74	133	119	25.5	39.2	4.4	3.5
	6/28/79	M	15.5	218	216	129	31	77	--	100	27.7	40.0	4.3	3.7
1083	5/25/77	M	7.5	120	188	115	31	70	117	110	24.0	36.0	3.2	2.8
	7/2/78	M	8.5	163	178	119	34	68	130	116	20.5	36.5	3.4	3.0
	6/30/79	M	9.5	161	190	120	27	69	124	116	21.0	36.4	3.2	3.0
1084	5/26/77	M	7.5	100	176	105	25	68	109	101	23.0	32.0	--	--
1085	5/27/77	F	19.5	127	190	102	27	66	119	100	21.2	35.0	2.9b	3.8
1086	5/29/77	F	16.5	93	159	101	24	61	120	98	20.1	31.4	3.2	2.4b
	6/24/77	F	16.5	107	--	--	--	--	--	--	--	--	--	--
	8/8/77	F	16.5	120	168	104	27	61	117	101	19.5	31.6	3.1r	2.6r
1087	5/29/77	F	1.5	14	94	48	18	35	60	53	12.5	18.5	--	--
	6/30/79	F	3.5	77	130	95	24	56	101	86	17.1	29.0	2.7	2.9
1088	5/31/77	M	4.5	122	164	110	27	62	112	100	18.5	34.0	3.5	3.4
1089	6/1/77	F	4.5	55	140	97	27	53	84	83	15.8	29.0	3.0	3.0
	6/10/77	F	4.5	57	--	--	--	--	--	--	--	--	--	--
1090	6/1/77	F	18.5	100	169	104	29	62	109	99	19.9	33.1	3.3	2.7w
1091	6/4/77	M	19.5	159	184	117	30	75	128	105	21.6	38.0	3.9	3.9
1092	6/4/77	F	8.5	100	168	92	25	68	107	100	19.9	32.5	3.1	2.8
1093	6/4/77	F	0.5	17	86	48	17	31	58	50	11.4	19.8	--	--
1094	6/5/77	M	4.5	79	165	111	32	57	94	96	17.3	32.2	3.2	3.0
1095	6/5/77	F	6.5	91	143	98	29	63	102	93	18.6	33.3	3.1	2.8
1096	6/5/77	M	7.5	147	180	108	32	71	122	103	20.5	37.2	3.5	2.9
	6/28/78	M	8.5	179	197	115	34	78	126	112	21.6	37.1	3.5	3.1
	6/28/79	M	9.5	--	193	114	27	75	135	107	22.5	38.0	3.3	3.1
1097	6/6/77	F	8.5	102	163	--	28	68	112	110	19.7	33.6	3.2	3.0

Appendix I. Continued.

Bear	Date	Sex	Age Cem^{2} (yrs)	Measured Weight	Total Length	Shoulder Height	Hind Foot	Neck	Girth	Body Length	Head Width	Head Length	Left Upper Canine^{3}	Left Lower Canine
1098	6/8/77	M	3.5	49	147	94	26	47	86	77	15.0	28.2	3.1	2.9
1099	6/11/77	M	10.5	166	186	129	30	79	128	112	21.9	38.5	3.7	3.5
	6/27/78	M	11.5	204*	198	120	30	76	128	112	22.6	38.8	3.9	3.5
	6/26/79	M	12.5	205	200	124	30	79	135	126	23.4	39.4	3.8	3.3
1100	6/11/77	F	6.5	91	163	98	26	59	98	100	17.2	32.4	2.7	2.7
	6/9/78	F	7.5	109	179	103	27	58	100	93	19.0	33.2	2.8	2.6
	7/1/79	F	8.5	100	170	--	29	62	99	101	19.3	32.8	3.0	2.8
1101	6/12/77	M	3.5	66	138	81	23	55	89	74	15.2	27.2	2.7	2.8
1102	6/12/77	F	3.5	57	138	82	25	50	85	68	14.6	26.7	2.6	2.4
	6/18/78	F	4.5	64	136	87	26	55	99	93	15.6	27.7	2.7	2.4
1103	6/12/77	M	8.5	145	187	120	33	71	117	104	20.3	37.1	3.7	3.1
	6/12/78	M	9.5	--	179	121	31	71	122	115	21.5	37.4	3.6	3.1
1104	6/12/77	F	9.5	98	165	97	30	61	108	88	19.0	32.9	3.3	2.7
1105	6/13/77	F	7.5	102	164	115	32	71	104	99	19.4	32.9	3.1	2.8
	6/28/78	F	8.5	129	170	106	31	66	111	117	19.9	33.8	3.4	3.0
1106	6/14/77	F	11.5	95	170	99	28	63	116	108	19.2	29.0	3.0	2.8
1107	6/14/77	F	0.5	3	--	--	--	--	--	--	--	--	--	--
1108	6/14/77	F	0.5	9	73	49	15	26	43	44	10.5	17.0	1.2	1.2
1109	6/14/77	F	0.5	8	63	49	13	26	45	41	10.1	16.1	1.0	1.1
1110	6/15/77	F	24.5	111	169	109	30	62	120	100	20.6	33.5	3.7	1.8b
	7/1/78	F	25.5	--	174	107	30	63	108	99	20.7	33.6	3.7	1.9b
	6/30/79	F	26.5	107	163	106	26	--	108	106	21.1	33.5	3.8	1.9b
1111	6/18/77	F	14.5	109	175	97	27	59	128	103	20.0	31.5	3.0	2.7
1112	6/18/77	M	4.5	113	165	103	31	62	109	109	19.1	33.3	3.4	3.0
1113	6/18/77	F	4.5	68*	157	96	--	55	--	84	16.8	29.8	2.9	2.9
1114	6/19/77	M	16.5	204	191	111	29	82	136	122	24.2	37.8	4.2	3.5b
1115	6/22/77	M	5.5	79	159	102	26	58	90	100	17.2	30.5	3.5	3.3
1116	6/23/77	M	5.5	79	170	100	29	53	108	101	17.8	32.1	3.3	3.0
1117	6/23/77	M	19.5	143	195	125	29	72	127	115	23.8	36.0	4.0b	2.9b

Appendix I. Continued.

Bear	Date	Sex	Age Cem[2] (yrs)	Measured Weight	Total Length	Shoulder Height	Hind Foot	Neck	Girth	Body Length	Head Width	Head Length	Left Upper Canine[3]	Left Lower Canine
1118	6/23/77	F	17.5	84	170	100	27	57	96	105	19.1	21.5	3.1	2.6
1119	6/24/77	F	6.5	86	158	101	23	60	102	86	18.1	30.4	2.8	2.6
1120	6/24/77	M	16.5	177	214	119	32	77	127	120	24.5	36.2	3.9	3.5
1121	6/25/77	F	11.5	111	174	102	24	65	104	122	19.5	33.2	3.0	2.7
1122	6/25/77	M	0.5	14	91	47	15	28	55	43	11.0	17.5	1.3	1.2
1123	6/25/77	F	0.5	12	85	55	16	29	47	49	11.5	16.8	1.3	1.1
1124	6/26/77	M	17.5	163	186	114	33	76	118	104	23.2	36.6	3.5	2.8b
1125	6/27/77	F	3.5	66	160	102	25	54	93	93	16.0	29.6	2.9	2.9
1126	6/28/77	M	13.5	156	181	116	33	77	128	119	24.2	36.9	3.5	3.3
1127	6/28/77	F	26.5	134	180	111	31	70	125	115	21.4	36.8	3.5	3.1
1128	6/30/77	F	7.5	109*	174	92	26	57	104	90	19.9	32.4	3.0	2.7
1129	6/30/77	F	1.5	41	128	79	23	43	74	75	14.2	25.1	0.6	0.9
1130	6/30/77	F	21.5	116	178	109	28	62	117	107	20.6	33.0	3.7	2.6
1131	7/1/77	M	8.5	107	176	116	28	63	105	107	19.0	33.0	3.3	3.1
1132	7/2/77	F	2.5	30	118	68	20	39	64	65	12.5	21.4	1.1	1.4
1133	7/2/77	M	2.5	36	123	77	23	43	67	74	13.7	23.7	0.9	0.5e
	6/27/79	M	4.5	68	150	94	25	48	87	84	16.1	29.3	3.0	2.8
1134	7/5/77	F	14.5*	104*	175	107	28	64	122	111	20.0	33.7	3.3	2.8
1135	7/5/77	M	1.5	26	100	58	19	38	70	65	12.4	21.8	e	e
1136	7/5/77	F	1.5	22	90	62	19	39	62	60	12.5	21.6	e	e
1137	7/5/77	F	1.5	26	104	52	19	36	59	65	12.8	22.6	e	e
1138	8/10/77	F	23.5	113	165	98	25	61	118	101	21.2	27.9	2.8	2.5b
	6/16/78	F	24.5	120	180	101	28	65	120	101	20.5	31.8	3.1	2.5
1139	6/7/78	F	11.5	91*	166	113	28	62	119	94	19.2	31.9	3.1	3.0
1140	6/7/78	M	0.5	10	70	46	13	28	45	42	10.5	16.0	d	d
1141	6/7/78	F	0.5	7	66	44	13	24	43	34	10.9	15.6	d	d
1142	6/9/78	F	14.5	113*	174	105	29	65	112	111	20.8	34.0	3.3	2.8
1143	6/9/78	F	9.5	95	172	96	27	56	96	101	20.5	32.6	3.2	2.7
1144	6/9/78	F	1.5	17	104	59	19	33	52	58	12.0	21.8	e	e

Appendix I. Continued.

Bear	Date	Sex	Age Cem[2] (yrs)	Measured Weight	Total Length	Shoulder Height	Hind Foot	Neck	Girth	Body Length	Head Width	Head Length	Left Upper Canine[3]	Left Lower Canine
1145	6/9/78	F	2.5	43	141	77	22	50	77	88	14.5	26.7	2.7	2.5
1146	6/9/78	F	14.5	104*	173	87	26	57	103	110	20.6	33.6	3.2	2.6
1147	6/9/78	M	3.5	93	163	99	27	56	99	94	17.1	33.1	3.8	3.3
1148	6/10/78	M	6.5	93	167	91	27	61	99	100	18.2	32.0	2.8	2.5
1149	6/11/78	F	4.5	82	160	90	26	51	91	90	17.2	30.1	2.7	2.6
1150	6/16/78	M	5.5	84	164	105	28	56	101	101	17.6	31.8	3.5	3.1
1151	6/16/78	F	3.5	51	134	75	24	46	82	73	15.0	26.7	2.8	2.8
1152	6/16/78	M	3.5	64	148	89	27	56	101	93	16.0	29.2	3.1	3.1
1153	6/16/78	F	3.5	32	124	67	21	40	71	68	14.0	23.0	0.9	2.4
1154	6/21/78	F	12.5	100	160	113	27	59	103	101	19.6	32.5	3.2	3.0
1155	6/21/78	M	1.5	34	115	77	21	39	70	67	13.3	24.1	e	d
1156	6/21/78	F	6.5	93	169	112	26	65	97	102	17.8	32.0	3.0	2.9
1157	6/24/78	M	5.5	95	165	104	30	65	99	107	18.8	33.7	3.3	3.1
	6/30/79	M	6.5	125	177	113	30	66	115	104	20.0	34.9	3.2	3.1
1158	6/24/78	F	7.5	82	153	103	29	53	93	94	17.7	30.8	3.1	2.8
1159	6/24/78	M	10.5	134	184	115	30	71	125	113	21.6	36.0	3.8	3.3
1160	7/1/78	M	0.5	11	76	43	14	27	48	45	10.7	18.1	d	d
1161	7/1/78	M	0.5	10	76	49	15	26	41	41	10.6	17.0	d	d
1162	7/1/78	M	2.5	43	120	82	24	50	75	71	14.4	24.7	2.6	2.9
1163	7/3/78	M	2.5	42	126	83	21	45	81	67	14.7	25.5	2.4	2.7
1164	5/7/79	M	3.5	84	166	98	26	55	101	81	17.5	31.5	3.2	3.1
1165	9/17/79	M	3.5*	90*	--	--	--	--	--	--	--	--	--	--
1166	9/18/79	F	9.5*	177	174	105	27	72	--	103	19.1	31.6	3.1	3.0
1167	9/18/79	F	10.5*	112	163	96	26	59	109	95	18.5	29.9	2.8	2.3
1168	9/18/79	F	0.5	20	107	50	18	40	74	--	11.6	20.5	d	d

* Estimate after close examination.
-- No data.

1 Weights in kg; measurements in cm.
2 Age determined by cementum layering.
3 Designations of tooth characteristics: b=broken; w=heavily worn; e=erupting; d=deciduous; r=right measured instead of left.

Appendix II. Capture and marker characteristics of 88 bears in the western Brooks Range, 1977-1979.

Bear No. and Sex	Cem. Age	Date of Capture	Bear Wt.[1]	Location	Drug Dosage[2]	Ear Tags[3]	Marking[4]
1081M	5.5	5/24/77	175	Utukok R.	2.6/H	889/890	P/O
	7.5	9/17/79	430	N. Meat Mtn.	M/O	17827/17826	P/O
1082M	13.5	5/25/77	370	Kokolik R.	2.0/0	892/893	0/G/0 (removed)
		6/13/77	365	Kokolik R.	2.3/0	892/893	0948
		6/25/77	380	Kokolik R.	2.7/0	892/893	1077/1127
		8/10/77	--	Kokolik R.	2.7/L	892/893	
	14.5	6/27/78	425	Kokolik R.	2.8/L	892/893	1580/1570 Bk 1640/1680
	15.5	6/28/79	430	Kokolik R.	M/O	313/312	1420/1007
1083M	7.5	5/25/77	265	Utukok R.	2.0/0	894/895	plaque
		6/2/77	--	Utukok R.	2.6/L	894/895	0998 Bk
	8.5	7/2/78	360	Utukok R.	2.7/0	894/895	0998 Bk
	9.5	6/30/79	355	Utokok R.	3.4/H	894/-	1023
1084M	7.5	5/26/77	220	Utukok R.	M/L	897/896	P/P
		6/2/77	--	Driftwood Cr.	2.2/L	897/896	0898 (lost) Bk/W
1085F	19.5	5/27/77	280	Meat Mtn.	M/L	899/898	1050
1086F	16.5	5/29/77	205	Meat Mtn.	2.0/L	205/206	1102/1152
		6/24/77	235	Meat Mtn.	1.3/L	205/206	
		8/8/77	265	Driftwood Cr.	1.9/0	205/206	
	18.5	9/16/79	400*	N. Meat Mtn.	M/L	205/206	1074.5/1410
1087F	1.5	5/29/77	31	Meat Mtn.	0.13/0	207/208	-/G
	3.5	6/30/79	170	Meat Mtn.	1.1/0	314/208	1480 Bk/-
1088M	4.5	5/31/77	270	Eskimo Hill	2.0/0	210/209	0923
1089F	4.5	6/1/77	122	Adventure Cr.	M/O	214/213	0973 (removed)
		6/10/77	126	Adventure Cr.	1.7/0	243/240	W/W
1090F	18.5	6/1/77	220	Utukok R.	M/H	215/216	0750
1091M	19.5	6/4/77	350	Utukok R.	3.0/H	217/218	0825
1092F	8.5	6/4/77	220	Ilingnorak Ridge	2.2/0	227/226	0775
1093F	0.5	6/4/77	38	Ilingnorak Ridge	0.1/0	228/229	1B/-
1094M	4.5	6/5/77	175	Meat Mtn.	2.0/H	225/230	1B/dB
1095F	6.5	6/5/77	200	N. Meat Mtn.	1.5/0	231/233	O/W
1096M	7.5	6/5/77	325	Meat Mtn.	2.6/0	236/237	0848
	8.5	6/28/78	395	Utukok R.	2.8/0	774/775	1596/1590 1B 1660/1700
	9.5	6/28/79	--	N. Meat Mtn.	M/H	774/775 & 893	-/1B
1097F	8.5	6/5/77	225	Meat Mtn.	1.8/0	235/234	0874
	8.5	6/19/77	--	Utukok R.	1.4/0	235/234	
1098M	3.5	6/8/77	108	Utukok R.	1.2/H	238/239	0/1B
1099M	10.5	6/11/77	365	Utukok R.	3.2/0	245/244	1023
	11.5	6/27/78	450*	Kokolik R.	2.8/0	773/772	1610/1560 1640/1680
	12.5	6/26/79	450	Utukok R.	3.0/0	773/772	1540

Appendix II. Continued.

Bear No. and Sex	Cem. Age	Date of Capture	Bear Wt.[1]	Location	Drug Dosage[2]	Ear Tags[3]	Marking[4]
1100F	6.5	6/11/77	200	Meat Mtn.	2.4/O	247/246	0973
	7.5	6/9/78	240*	Utukok R.	2.5/H	247/246	0973P
	8.5	7/1/79	220	Driftwood Cr.	1.9/O	246/247	1098 P
1101M	2.5	6/12/77	145	Utukok R.	1.2/L	249/248	G/W
1102F	2.5	6/12/77	125	Utukok R.	1.2/L	251/250	W/G
	3.5	6/18/78	140	Utukok R.	1.4/O	251/250	1470
1103M	8.5	6/12/77	320	Utukok R.	2.6/H	253/252	1002 broken
	9.5	6/12/78	--	Utukok R.	M/H	253/252	1510
1104F	9.5	6/12/77	215	Utukok R.	1.6/O	255/254	0800
		6/17/77	--	Utukok R.	1.2/L	255/254	0800
1105F	7.5	6/13/77	225	Kokolik R.	1.5/O	257/256	1098
		6/26/77	245	Tupikchak Mtn.	1.5/L	257/256	1098/1148
	8.5	6/28/78	285	Kokolik R.	1.7/L	257/301	1620/1630
1106F	11.5	6/14/77	210	Adventure Cr.	1.5/H	258/259	0724
1107F	0.5	6/14/77	6.5	Adventure Cr.	none	none	none
1108F	0.5	6/14/77	20	Adventure Cr.	none	-/260	-/W
1109F	0.5	6/14/77	18	Adventure Cr.	none	261/-	W/-
1110F	24.5	6/15/77	245	Ilingnorak Ridge	M/H	262/263	1B/P/1B
	25.5	7/1/78	--	Ilingnorak Ridge	1.9/L	262/263	1074.6 dB
	26.5	6/30/79	235	Ilingnorak Ridge	1.7/H	262/263	0725
1111F	14.5	6/18/77	240	Colville R.	1.7/O	269/268	0700
1112M	4.5	6/18/77	250	Colville R.	1.7/O	267/266	dB/G
1113F	4.5	6/18/77	150*	Colville R.	1.5/O	270/271	G/dB
1114M	16.5	6/19/77	450	Utukok R.	1.7/L	273/272	O/G/O
1115M	5.5	6/22/77	175	Meat Mtn.	1.5/H	275/274	dB/O
1116M	5.5	6/23/77	175	Utukok R.	1.5/O	276/277	O/dB
1117M	19.5	6/23/77	315	Driftwood Cr.	M/O	279/278	Pp/W/Pp
1118F	17.5	6/23/77	185	Driftwood Cr.	1.3/H	281/280	W/Pp
1119F	6.5	6/24/77	190	N. Meat Mtn.	1.7/L	282/283	O/P
1120M	16.5	6/24/77	390	N. Meat Mtn.	2.6/O	284/285	Pp/1B/Pp
1121F	11.5	6/25/77	245	Kokolik R.	M/H	287/286	1079/1128
1122M	0.5	6/25/77	30	Kokolik R.	0.12/O	-/288	-/G
1123F	0.5	6/25/77	27	Kokolik R.	0.12/O	289/-	G/-
1124M	17.5	6/26/77	360	Tupikchak Mtn.	2.6/O	291/290	dB/W/dB
1125F	3.5	6/27/77	145	Utukok R.	1.4/H	-/292	-/W
1126M	13.5	6/28/77	345	Kokolik R.	2.7/O	293/294	O/W/O
1127F	26.5	6/28/77	295	Kokolik R.	1.5/L	295/-	P/W/P
1128F	7.5	6/30/77	240*	Tupikchak Mtn.	1.8/O	297/296	P/P/P
1129F	1.5	6/30/77	90	Tupikchak Mtn.	0.5/O	299/298	P/P
1130F	21.5	6/30/77	255	Elbow Cr.	1.9/O	300/900	O/O/O
1131M	8.5	7/1/77	235	Driftwood Cr.	2.5/H	3085/3086	G/O
1132F	1.5	7/2/77	67	Archimedes Ridge	--	1498/3082	1B/P
1133M	1.5	7/2/77	80	Archimedes Ridge	--	3088/1499	P/1B
	3.5	6/27/79	150	Utukok R.	1.4/O	310/309	P/1B

Appendix II. Continued.

Bear No. and Sex	Cem. Age	Date of Capture	Bear Wt.[1]	Location	Drug Dosage[2]	Ear Tags[3]	Marking[4]
1134F	14.5*	7/5/77	230*	Utukok R.	2.0/L	3089/3090	0947 O
1135M	1.5	7/5/77	57	Utukok R.	--	3091/3092	O/O
1136F	1.5	7/5/77	48	Utukok R.	--	3093/-	O/-
1137F	1.5	7/5/77	58	Utukok R.	--	-/3094	-/O
1138F	23.5	8/10/77	250	Kantangnak Cr.	1.9/O	none	0898 O lost
	24.5	6/16/78	265	Kantangnak Cr.	M/L	759/758	dB/dB/dB
1139F	11.5	6/7/78	200*	Utukok R.	1.3/O	651/654	1549W
1140M	0.5	6/7/78	21	Utukok R.	none	-/655	-/O
1141F	0.5	6/7/78	16	Utukok R.	none	656/-	O/-
1142F	14.5	6/9/78	250*	Utukok R.	M/H	658/657	1520 Bk
1143F	9.5	6/9/78	210*	Utukok R.	1.8/H	704/705	1B/W
1144F	1.5	6/9/78	38	Utukok R.	0.4/H	717/718	Pp/G
1145F	2.5	6/10/78	95	Elbow Cr.	1.7/H	720/719	1457 1B/G
1146F	14.5	6/10/78	230*	Elbow Cr.	2.5/H	721/722	G/1B
1147M	3.5	6/10/78	205	Utukok R.	1.3/O	723/724	P/G
1148M	6.5	6/10/78	205	Utukok R.	1.3/O	725/728	dB/W
1149F	4.5	6/11/78	180	Utukok R.	1.3/O	736/733	W/dB
1150M	5.5	6/16/78	185	Utukok R.	1.2/O	751/747	Bk/P
1151F	3.5	6/16/78	112	Kantangnak Cr.	--	752/753	Bk/Bk
1152M	3.5	6/16/78	142	Kantangnak Cr.	--	754/755	1450 O/Bk
1153F	3.5	6/16/78	70	Kantangnak Cr.	--	756/757	Bk/O
1154F	12.5	6/21/78	220	Tupik Cr.	1.8/O	760/761	W/O/W
1155M	1.5	6/21/78	75	Tupik Cr.	0.5/O	763/762	G/W
1156F	6.5	6/21/78	205	Kogruk Cr.	2.0/O	765/764	P/Bk
1157M	5.5	6/24/78	210	Driftwood Cr.	M/H	766/767	P/G/P
	6.5	6/30/79	275	Driftwood Cr.	2.4/H	766/767	Bk/P
1158F	7.5	6/24/78	180	Elbow Cr.	1.4/O	769/768	P/W
1159M	10.5	6/24/78	295	Driftwood Cr.	1.7/O	770/771	G/P
1160M	0.5	7/1/78	25	Ilingnorak Ridge	none	303/-	dB/-
1161M	0.5	7/1/78	21	Ilingnorak Ridge	none	-/302	-/dB
1162M	2.5	7/1/78	95	Iligluruk Cr.	1.1/O	304/305	1490 1B/Bk
1163M	2.5	7/3/78	92	Iligluruk Cr.	M/H	306/307	1440 Bk/1B
1164M	3.5	5/7/79	185	Meat Mtn.	1.3/O	311/308	1498 G/Bk
1165M	3.5*	9/17/79	200*	N. Meat Mtn.	M/H	318/319	G/dB
1166F	9.5*	9/18/79	390	N. Meat Mtn.	M/L	284/317	08980 dB/O
1167F	10.5*	9/18/79	235	N. Meat Mtn.	2.8/H	271/315	1533 O/dB
1168F	0.5	9/18/79	55	N. Meat Mtn.	.60/O	274/296	R/Y eartags

* Estimate after close examination.

[1] Weight in pounds.

[2] Dosage in cc of Phencyclidine hydrochloride; M denotes multiple dosage with unknown effective dosage. Drug effects were as follows: L, light, O, optimum, H, heavy.

Appendix II. Continued.

3 left/right

4 Marker designations:

<u>Colors</u>: P, pink; W, white; G, light green; O, orange; dB, dark blue; lB, light blue; Bk, black; Pp, purple.

<u>Marker types</u>:

One or two color combinations were used for ear flags; e.g. O/W is orange in left ear, white in right ear; -/G is no flag, left; green, right. Three flag combinations were used in nylon rope collars; e.g. OOW is two identical clusters of OOW flags on opposite sides of the collar. Numbers, such as 1470, designate a radio collar with a frequency of 151.470 kHz; some radio collars were also marked with a flag and some transmitted more than one frequency.

Appendix III

1978
PRELIMINARY REPORT

Behavioral Ecology of a Barren-Ground Grizzly Bear Female and Her Young in the National Petroleum Reserve-Alaska

by

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This 2-year study has been funded by the Alaska Department of Fish and Game through the U.S. Fish and Wildlife Service, the Arctic Institute of North America, the Audubon Society, the National Wildlife Federation, the Theodore Roosevelt Fund of the American Museum, the Naval Arctic Research Laboratory and the University of Montana.

INTRODUCTION

During 1978 various aspects of the ecology of a barren-ground grizzly bear (*Ursus arctos*) female and her offspring were examined. Basic food habits and habitat use information were already available as a result of work done in the summer of 1977 (Hechtel 1977). This work was continued in 1978 and, in addition, data on movement, home range, activity patterns and behavior were collected. In order to correlate habitat use with habitat availability, sampling of important vegetation types in the area was conducted.

OBJECTIVES

1. To examine in detail the seasonal food habits of a female grizzly and her two offspring, and to provide a general account of bear food habits on the western North Slope.

2. To determine daily movement and activity patterns, seasonal movements and the home range of the bears.

3. To describe and map portions of habitat within the home range of the family group.

4. To determine the seasonal habitat use patterns of the bears.

5. To conduct qualitative analyses of important bear food items.

PROCEDURES

The study area centered around Meat Mountain (68°56'N 160°45'W), National Petroleum Reserve-Alaska (NPR-A). Meat Mountain was chosen for the study area because of the presence of a female grizzly with offspring on the slopes of this large mesa. This situation provided excellent viewing conditions from the top of the mesa while generally separating observers from bears by a steep talus slope. The open nature of tundra vegetation as well as the extended period of daylight in midsummer also facilitated observation.

The study was conducted in cooperation with an ongoing Alaska Department of Fish and Game (ADF&G) bear research program in the NPR-A (Reynolds 1977). Field work was carried out from 28 May 1977 through 11 September 1977, and from 19 May 1978 through 21 September 1978. Detailed information obtained on one family group by ground-tracking and direct observation in this study was planned to complement broad-scale population biology, movement, and habitat use data gathered through capture and radio-tracking of grizzlies by ADF&G. Bears were captured using a helicopter and marked with individually coded, colored flags or fitted with radio transmitters of specific frequencies. During 1977, grizzly no. 1086, a female accompanied by two yearlings, was fitted with a radio collar. The radio collar permitted tracking of no. 1086 and her offspring throughout the 1977 and 1978 field seasons. Periodic aerial tracking by ADF&G located the bears when we were unable to locate them from the ground. In addition to no. 1086 and her cubs, at least nine other bears used the study area periodically and were watched for brief periods of time. In order to compare food habits and habitat use patterns of no. 1086 with those of other bears, female no. 1092 and her yearling were observed from 12-19 June 1978 in the vicinity of Ilingnorak Ridge, about 25 miles southwest of Meat Mountain.

Observations of these grizzlies provided information on habitat use, food habits, home range, movements and activity patterns. Feeding sites or areas actively used by bears were examined when the bears moved away. Descriptions of habitats, plant species present and feeding site information were recorded. Voucher specimens of plants and bear scats were collected. Samples of important plant species utilized by bears were also collected from the feeding sites and frozen, dried or preserved in ethanol. Scat samples from eight immobilized bears collected during ADF&G research will be analyzed for parasite content. Eight phenology plots, 4 each on the north and south exposures, and 15 vegetation transects in various habitats were run.

PRELIMINARY FINDINGS

Movement, Home Range and Activity Patterns

During 1977 no. 1086 and her yearlings occupied a home range of approximately 112 sq. mi. in the vicinity of Meat Mountain (Reynolds 1977). Their movements in the early spring were restricted to the relatively steep, north-facing slope of Meat Mountain. As the season progressed movements became more extensive. The bears wandered as far as the junction of Driftwood Creek and the Utukok River, even though they still spent most of their time on the slopes of Meat Mountain. They denned together on the northwest side of Meat Mountain on 9-10 October 1977 (Reynolds 1977).

In 1978 they emerged from the den between 20 April and 12 May. The offspring, now 2-year-olds, remained with no. 1086 the entire field season. Their home range was essentially the same as the year before, except that movements, especially in early spring, were more extensive. During direct observation sessions movements of the family group were recorded on mylar overlays on aerial photographs. Movement data will be analyzed and presented in the final report. The bears denned together on Meat Mountain between 4-9 October at the head of a drainage on the southwest side of the mountain within 1 mile of the 1977 den site.

The home range of the bears included a mosaic of most available habitat types. The diversity of habitats was due to the varied nature of local relief in the northern foothills. From almost any portion of the bears' home range it is not necessary to move more than a few miles to reach almost any other vegetation type. However, the bears wandered more widely than necessary to satisfy their vegetative needs. For instance, the family group often traveled several miles while feeding in wet sedge meadows, leaving behind an apparently abundant food source of the same type to move to areas that were ostensibly similar in composition and phenology. One explanation for such moves could be that as long as their basic vegetative needs were supplied throughout a large area it was more efficient for them to move while feeding in order to take advantage of chance food items such as a vulnerable caribou (*Rangifer tarandus*), carrion, or nesting birds. When they did encounter a limited food source of high energy value, such as dead caribou, it was probably advantageous to remain at the site until the carcass was consumed.

The direct observation sessions not only provided data on habitat use and movements, but provided the opportunity to watch the bears' behavior. Table 1 lists the dates and times when direct observations of individual bears were made. A total of 278.7 hours of direct observation were logged during the 1978 season. Bear activity was broken down into a number of categories: resting, feeding (nursing, grazing, digging roots, digging ground squirrels [*Spermophilus parryii*]), foraging, travel and play. Data from observation periods are now being analyzed. A certain amount of information on the bears' activity patterns can be extracted from the data. There was an apparent tendency, for example, for an extended sleep period during midday, although a considerable amount of variation was involved. Observations of nursing behavior, some data on success rates when digging for ground squirrels, observations of intraspecific encounters and some information on the effects of disturbance were recorded. Differences in behavior of females toward their offspring were noted between no. 1086 and no. 1092. Female no. 1086 was much more tolerant of crowding by her young during feeding and even permitted them to take ground squirrels from the holes she was digging. Female no. 1092, on the other hand, made her cub keep its distance and in the short time we observed her was more aggressive toward it. These behavioral data will be presented in detail in the final report.

Habitat

In order to describe and map portions of bear habitat and to record habitat use patterns for no. 1086 and her young, a general reconnaissance of the major vegetation types was conducted in 1977. Important plants were identified, voucher specimens were collected, and plant species lists for some of the habitats begun. During 1978 more detailed analyses were carried out including phenology plots and vegetation transects. General habitat mapping was done on aerial photographs of the area. In addition, direct observations of the bears' activities revealed actual use of the different habitat types during the study periods.

A tentative breakdown of the major habitat types found in the study area includes:

Fellfield-Barrens
Talus
Dryas - dwarf shrub
Dryas - step and stripe
Carex Bigelowii meadow
Tussock tundra
Betula tussock
Betula thicket
Wet sedge meadow
String bog
Riparian
Late snowbank community

Table 1. Periods of intensive observation of grizzly bear activity, 1978.

Date	Time	Hours of Observation	Bear
30-31 May	2400-2400	24:00	1086/2 young
2-3 June	1200-1315	25:15	1086/2 young
8 June	2030-2245	2:15	1086/2 young
9 June	1200-1240	:40	1086/2 young
12 June	1200-2045	8:45	1092/1 young
15 June	1530-2400	8:30	1092/1 young
24 June	1115-1243	1:28	1086/2 young
24 June	1430-2100	6:30	Unmarked
24 June	1725-2100	3:35	1114 male
25 June	2030-2210	1:40	1086/2 young
26 June	1530-1645	1:15	1086/2 young
27 June	1445-1700	2:15	1086/2 young
29-30 June	1400-1830	28:30	1086/2 young
2 July	1330-2210	8:40	1086/2 young
3-8 July	Transmitter Problem		
14 July	1230-1415	1:45	1086/2 young
14-15 July	1630-1630	24:00	1086/2 young
23 July	2030-2105	:35	1096 male
23-24 July	2100-0303	6:03	1086/2 young
24 July	0100-0205	2:05	1096 male
24 July	0446-0453	:07	1086/2 young
24 July	0658-2359	17:01	1086/2 young
25 July	1530-1942	4:12	1086/2 young
31 July	1100-2400	13:00	1086/2 young
2-3 August	2230-0116	2:46	1086/2 young
4 August	2400-1314	13:14	1086/2 young
15 August	0430-0530	1:00	1131 male
16 August	1435-1506	:31	1096 male
16 August	2100-2210	1:10	1131 male
16 August	2030-2300	2:30	1086/2 young
17 August	1000-1430	4:30	Unmarked
17 August	1745-2005	2:20	Unmarked
17 August	1849-2328	4:39	1086/2 young
19 August	2200-2330	1:30	1086/2 young
25 August	0925-2028	11:03	1086/2 young
30 August	1545-2224	6:39	1086/2 young
31 August	0700-2132	14:32	1086/2 young
7 September	1500-2045	5:45	1086/2 young
11 September	0945-1630	6:45	1086/2 young
13 September	1330-2111	7:41	1086/2 young
		278:41 total	

This is not a final breakdown but gives an idea of the range of vegetation types encountered. One of the problems of working with tundra vegetation is the lack of a good, standard classification system. Systems in use range from the simple classifications of Spetzman (1959) to an attempt to synthesize the various named botanical units into a comprehensive, provisional classification of Alaskan Arctic tundra by Murray and Batten (1977). In-depth habitat discussion and the relative merits of different systems for classifying grizzly habitat will be dealt with in the final report.

Habitat data will be analyzed this winter and the occurrence of important bear foods will be correlated with habitat types. Species lists, composition and phenology information will be presented, as well as the data on seasonal habitat use by bears. Habitat use patterns can be summarized as follows:

Season	Main Habitat Types Used
Pre-growing through early growing season: May through early June	*Dryas* step and stripe; *Dryas* dwarf shrub; floodplain
Growing season: early June through late July	Wet sedge meadow; late snowbank community; tussocks
Post-growing season: early August through denning in early October	Floodplain; *Dryas* step and stripe; *Dryas* dwarf shrub; *Betula* tussocks; string bogs

This summary is preliminary and generalized; a more detailed breakdown and explanations beyond the scope of this progress report will be dealt with in the final report.

Apparently the major habitat use patterns outlined above were primarily a function of plant availability. However, superimposed on the vegetation-influenced use patterns, the search for carrion and prey, especially ground squirrels, draws bears into areas where the vegetation of a habitat type is not used as food. Thus, in midsummer grizzly bears may be found most often in wet sedge meadows along small drainage ways feeding on the vegetation, yet they also travel to raised frost-scarred *Dryas* areas in search of ground squirrels.

Habitat use is also affected by local variations in the availability and abundance of potential food sources. An abundant crowberry crop (*Empetrum nigrum*) might shift fall use more to *Betula* tussock areas, or a good blueberry crop (*Vaccinium uliginosum*) might draw bears into the string bogs. No. 1086 was observed in the fall of 1978 in a string bog digging up microtine sedge root caches. In years of high microtine populations, an increased incidence of cache-raiding and predation on microtines would be expected. Bears are opportunistic omnivores, and their habitat use patterns reflect it.

Portions of the bears' habitat are being mapped on aerial photographs on the basis of data collected during the 1977 and 1978 field seasons. In addition, two different LANDSAT vegetation maps of the area are available, and high altitude infrared photos were obtained. These will be compared to the grizzly habitat use maps in order to determine their applicability for bear habitat inventory. High altitude color photography at certain key times in spring and fall could be an extremely valuable aid in mapping tundra. Differences in the timing of the spring emergence of plants and the change to fall colors between vegetation types can be used to separate locations and boundaries of habitat types which would otherwise be very difficult to map from the ground. A serious limitation, however, is the fact that the period when differentiation between types is evident often lasts only a few days and inclement weather or problems with aircraft may preclude plans for obtaining the photographs.

Food Habits

Direct observations of feeding activity, feeding site examinations, field observations on scat contents during 1977 and 1978, and preliminary lab analyses of scats from 1977 were all used to document bear food habits. Table 2 outlines the generalized food habits of grizzly bears in the study area. This summary is based on the intensive work on no. 1086 and her young and on occasional data from other bears.

While many foods were eaten, grizzlies seemed to concentrate on relatively few. The most important seasonal foods appeared to be:

Pre-growing season	Growing season	Post-growing season
Hedysarum alpinum-roots	grasses and sedges	*Hedysarum alpinum*-roots
Oxytropis borealis-roots	*Boykinia Richardsonii*-leaves, stems & flowers	*Arctostaphylos rubra*-berries
Arctostaphylos rubra-overwintered berries	*Equisetum arvense*-fruiting & vegetative stems	*Spermophilus parryii*-ground squirrels

The majority of their diet consisted of plant material; whenever possible, however, caribou, ground squirrels, marmots (*Marmota caligata*), microtine rodents and birds were eaten.

Over 350 scats were collected during the 1978 field season and will be analyzed this winter. In addition, 198 scats were collected during 1977 and analyzed last winter. The scats were labeled with as much information as possible, including date collected, location, vegetation type, relative age, bear number and (during 1978) diameter in millimeters. Black bears do not occur in the area so there were no problems identifying grizzly scats.

Table 2. Preliminary seasonal food habits summary for grizzly bear No. 1086 and her young based on direct observations, feeding site examination and some scat analysis.

		Amount of use		
Type of Food	Species	Den emergence to early growing season (May-early June)	Growing season (early June-end of July)	Late growing season to denning (August-early October)
Roots	Hedysarum alpinum	4-5	0	5
	Oxtropis borealis	3-5	0	0
	Sedge (from microtine caches)	2*	0	2*
Leaves and stems	Grasses and Sedges	0	5	0
	Boykinia Richardsonii	3	5	0
	Equisetum arvense (both brown fertile stems and vegetative stems used)	3	4-5	0
	Oxyria digyna	0	2	0
	Salix sp. (leaf buds)	1	0	0
Flowers	Oxytropis borealis	0	2	0
	Boykinia Richardsonii	0	4	0
	Salix sp. (catkins)	1	0	0
Fruit	Arctostaphylos rubra	3	0	5
	Vaccinium uliginosum	0	0	*
	Vaccinium vitis-idaea	0	0	*
	Empetrum nigrum	0	0	*
Carrion	Rangifer tarandus	2-3	2	2
	Alces alces	0	0	0
Prey	Rangifer tarandus	3	2	1
	Spermophilus parryii	4	3-4	5
	Marmota browerii	1	1	1
	Lagopus sp.	1	1	1
	Microtine rodents	*	*	*
	Bird eggs	1	1	0
	Insects	1	1	1

0 = none observed; 1 = rare; 2 = occasional; 3 = light; 4 = moderate; 5 = heavy;
* = use fluctuates greatly with food availability

Qualitative Food Analysis

Calorimetry Studies

During 1977 major food items used by grizzly bears were identified, and samples of both individual plant species used as food and the same plant species from a bear scat were collected. In 1978 some additional samples were obtained for calorimetric analysis. These matched food/scat samples are being analyzed as part of a digestive efficiency study by Dr. Erich Follmann of the Naval Arctic Research Lab at Barrow.

Crude Protein and Crude Fiber Analyses

Samples of important food items identified in 1977 were gathered and dried during the 1978 field season and will be analyzed for crude protein and crude fiber. In addition to the single samples of most of the foods, a series of samples of the roots of *Oxytropis borealis* and *Hedysarum alpinum* were obtained.

Soluble Carbohydrate

Soluble carbohydrate content is probably one of the best indications of food value for grizzly bears. Difficulty in preparing specimens under field conditions prevented the collection of very many samples. However, Peggy Kuropat, a graduate student from the University of Alaska working on caribou foods, was collecting plant samples for soluble carbohydrate analysis. A number of the plant species she will be analyzing, such as *Boykinia Richardsonii* and *Equisetum arvense*, are used by grizzlies, so Kuropat's data on a number of important midsummer foods will be available. It was also possible to use her equipment to obtain a number of samples of fall grizzly foods which John Bryant (University of Alaska) has agreed to analyze this winter.

Table 3 lists the various food items and samples collected. The numbers of samples to be analyzed for crude fiber and crude protein will depend on the adequacy of available funding.

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Table 3. Samples of plant food items used by grizzly bears which were obtained for qualitative analysis.

Type of Food	Species	In Literature	Observed	Samples obtained: Calorimetry Food	Samples obtained: Calorimetry Scat	Samples obtained: Soluble Carbohydrate	Samples obtained: Crude protein and fiber
Roots	*Hedysarum alpinum*	X	X	X	X	X	X
	Oxytropis borealis	-	X	X	X	X	X
	Sedges (*Carex* sp. or *Eriophorum* sp.)	?	X	X	?	X	X
	Petasites sp.	X	-	X	-	-	-
Leaves and Stems	*Boykinia Richardsonii*	X	X	X	X	X*	X
	Equisetum arvense	X	X	X	X	X*	X
	Oxyria digyna	X	X	X	?	?	X
	Grasses and sedges	X	X	-	-	-	-
	Arctagrostis latifolia	X	-	-	-	-	-
	Calamagrostis canadensis	X	-	-	-	-	-
	Salix sp. (buds)	X	X	-	-	X*	-
Flowers	*Oxytropis borealis*	-	X	X	-	-	-
	Boykinia Richardsonii	X	X	X	-	-	-
	Salix sp. (catkins)	X	X	-	-	-	-
Fruit	*Arctostaphylos rubra*	X	X	X	X	X	X
	Vaccinium uliginosum	X	-	X	-	X	-
	Vaccinium vitis-idaea	X	-	X	-	X	X
	Empetrum nigrum	X	-	X	-	X	X
	Shepherdia canadensis	X	(not found in study area)				

*Being analyzed as part of a caribou study by Peggy Kuropat, University of Alaska.

JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Harry V. Reynolds		
Project No.:	W-17-11	Project Title:	Big Game Investigations
Job No.:	4.15R	Job Title:	Characteristics of Grizzly Bear Predation on Caribou in the Calving Grounds of the Western Arctic Herd
Period Covered:	July 1, 1978 through June 30, 1979		

SUMMARY

Grizzly bear use of caribou as carrion and prey was investigated in the vicinity of the caribou calving grounds of the Western Arctic Herd. Caribou aggregations were available to grizzlies during spring migration, calving, post-calving migration, and post-calving shift; most of the grizzly bear predation and scavenging in 1979 occurred during post-calving migration. The availability of caribou to grizzlies was dependent on caribou moving into the home ranges of the bears; no bears were observed leaving home ranges to reach caribou aggregations. The proportions of caribou which were killed by bears and those which were scavenged were not determined. Although most caribou killed by bears were calves, adults were also preyed upon. Grizzlies of all sex and age classes fed on caribou, but adult males were probably the most successful in killing or scavenging caribou or at least in gaining possession of carcasses which other bears killed or scavenged. Although the specific effects of availability of caribou on individual bears were not determined, the fact that the grizzly bear population in this area has a higher density and productive potential than other North Slope grizzly populations was ascribed to the availability of caribou as a food source.

CONTENTS

BACKGROUND

Grizzly bears (*Ursus arctos*) and ungulates have long coexisted throughout North America. Although grizzlies feed primarily on vegetation, these bears also consume a wide variety of animal matter, including ungulates as carrion and prey. In the past even though it was generally acknowledged that grizzlies could cause serious losses of domestic livestock, the effects of grizzly bear predation on wild animals including moose (*Alces alces*) and caribou (*Rangifer tarandus*) populations in Alaska were felt to be negligible (Lent 1964, Skoog 1968, Franzmann and Schwartz 1979). Recently, however, there has been growing evidence that predation by both black bears (*Ursus americanus*) and grizzlies was responsible for depressing survival rates of moose calves in some areas of Alaska (Ballard et al. 1979, Franzman and Schwartz 1979). Observations of grizzlies killing caribou have been made (Lent 1964, Skoog 1968, Reynolds 1978), but the effects of grizzly bear predation on caribou populations have not been investigated.

In 1970 the Western Arctic Herd (WAH) included at least 242,000 caribou and was the largest caribou population in Alaska (Hemming 1971). By 1975 this herd had declined to a minimum of 100,000 animals; by 1976 it had declined further to a minimum of 64,000 (Davis 1978, Davis and Valkenburg 1978). The major causes of this decline were overharvest by hunters, including losses due to wounding and waste, and predation, primarily by wolves (*Canis lupus*). Beginning in 1977 the WAH began to recover and by 1979 it numbered about 113,000 (J. Davis, pers. comm.). This increase was probably due in part to a decreased kill by hunters, which was brought about by regulatory changes, and to the wintering of a large proportion of the herd on the northern coastal plain where wolf density, and thus predation, was very low.

This precipitous decline and partial recovery of the WAH emphasized the need for additional insight into the population dynamics of caribou, particularly those concerning rates and causes of natural mortality. Davis and Valkenburg (1979) began to study natural mortality of caribou in 1979; their investigations focused on mortality of young age and adult animals during periods other than calving and post-calving migration.

Numerically, most mortality in caribou herds occurs to calves within the first 8 weeks after birth. The factors responsible for neonatal mortality in this herd are not fully understood. However, causes of neonatal mortality in a Canadian caribou population, listed in decreasing order of importance, were: predation (by wolves), abandonment by maternal cows, stillbirths, physiological or pathological disorders (nonspecific), pneumonia, malnutrition, and injuries (Miller and Broughton 1974). These causes of mortality are very likely similar to those responsible for calf losses in the WAH except that wolves are responsible for very little neonatal mortality. In the WAH, during calving, caribou are largely unavailable to wolves but are available to grizzly bears and small predators including golden eagles (*Aquila chrysaetos*), red foxes (*Vulpes fulva*), Arctic foxes (*Alopex lagopus*), and wolverines (*Gulo gulo*).

Grizzly bears are the largest and probably the most successful predator of calves on the WAH calving grounds and along the post-calving migration route. Grizzly densities are generally sparse on the north slope of the Brooks Range, averaging 1 bear/260 km^2. However, the density of bears in the vicinity of the WAH calving grounds in the Utukok/Kokolik River uplands is 1 bear/44 km^2 (Reynolds 1978). Not only are grizzlies more dense in this area, but they are more productive than grizzlies studied in the eastern North Slope as well (Reynolds 1976, 1978): females breed successfully at a younger mean age, 8.4 vs. 10.1 years; mean litter size is larger, 2.0 vs. 1.8; and reproductive interval is shorter, 4.0 vs. 4.2 years. The fact that grizzlies are more numerous and more productive in the vicinity of the WAH calving grounds is probably due to the availability of caribou as prey and carrion for grizzly bears (Reynolds 1977).

Lent (1964) observed grizzlies killing calves in this area but estimated that the effect of grizzly-caused mortality on the WAH caribou population was negligible. However, even though predation was a negligible mortality factor when the herd size was large, it is much more likely to have an effect now that herd numbers have dwindled. The extent of grizzly bear predation on caribou and the conditions under which this predation occurs must be known in order to accurately assess the importance of grizzly bear predation on the growth of the WAH.

Population studies of WAH caribou have been conducted in this area since the early 1960's and continue to the present time (Lent 1964; Skoog 1968; Hemming 1971; Davis 1978; Davis and Valkenburg 1978, 1979; Davis et al. 1979, In Press). There is also a data base for grizzly bear population biology, food habits, and movement patterns (Reynolds 1977, 1978, this volume). A large percentage of the grizzlies in the area are individually color-marked or radio-collared, a fact which greatly facilitates further investigations involving predation behavior.

OBJECTIVES

To determine the extent of grizzly bear predation on caribou in the vicinity of the calving grounds of the Western Arctic Herd, characterize the sex and age classes of grizzly bears which prey on caribou, and determine the effect of caribou availability as prey and/or carrion on grizzly bear productivity.

PROCEDURES

The study area included the core caribou calving grounds of the WAH, the area used in post-calving migration from the calving grounds southwest to the Kukpowruk River, and the area south of the calving grounds where Reynolds (1978) studied grizzly bear population biology and habitat use. The core calving grounds of the WAH may shift from year to year but is generally centered in the foothills between the Utukok and Kokolik Rivers, near Avingak Creek, and northwest of the confluence of Carbon Creek and the Utukok River (Lent 1964, Davis and Valkenburg 1978). This area is 150 to 600 m above sea level and consists of rolling hills and upland meadows. From the calving grounds the study area extends southward to the Brooks Range. The post-calving migration route is generally southwest from the calving grounds toward Mt. Kelly and across the Kokolik and Kukpowruk Rivers.

In order to determine the effect of grizzly bear predation on the WAH, it was necessary to learn the number of calves lost to all causes of natural mortality as well as the number of calves killed by grizzlies. The chronology of neonatal mortality was assessed by determining the number of calves:100 cows at the peak of calving, during the post-calving migration, during post-calving shift movements, and during fall migration. The chronology of calving and changes in calf:cow ratios were determined by observers from the ground in the core calving area and from the air in the core and peripheral calving areas. These observations were to continue until post-calving migration composition counts were made in conjunction with an aerial photo-direct count-extrapolation (APDCE) census (Davis et al. 1979). From observations of the proportion of cows with calves and cows without calves but with distended udders, an estimate can be made of: 1) the number of calves produced, 2) the number of calves surviving until post-calving migration, and 3) the number of calves which died between birth and post-calving migration.

Grizzly bear predation on calves was to be determined by several means, some of which were not successfully accomplished. The chronology of caribou calving and changes in calf numbers were determined by observers from the ground in the core calving area and from the air in the core and peripheral calving areas. These observations continued until the post-calving migration composition counts were made in conjunction with the APDCE census estimate. From observations of the proportion of cows with calves and cows with distended udders, an estimate was made of the number of calves produced, the number surviving until post-calving migration, and the number which died between birth and post-calving migration. An effort was made to determine the cause of death of all calves found by ground crews.

Two bears which were observed on the calving grounds or killing caribou were to be fitted with radio transmitter collars and followed by a ground crew to determine the number and age of caribou which were killed or which were eaten as carrion. In addition, observers in aircraft were to locate all radio-collared bears in the calving grounds twice daily to determine the number of caribou carcasses which radio-collared bears of known sex and age consumed. Data obtained from the two bears followed on the ground were to be utilized as a control to determine the accuracy of data collected by aircraft observers. The amount of bear predation on caribou was to be estimated by relating the number of caribou killed by radio-collared bears to the number killed by all bears on the calving grounds. The effect of availability of caribou calves, as prey or carrion, on the productivity of bears was to be determined by comparing the productivity of females utilizing caribou to that of females for which caribou were not available.

The methodology was predicated on plans by the Alaska Department of Fish and Game (ADF&G) to conduct an APDCE caribou census of the Western Arctic Herd during summer 1979. This planned census was to enable both the census project and this project to share in the use of aircraft, cooperation which would have resulted in a longer period of availability of helicopter and light plane support. However, due to unexpected budget shortfalls on a Department-wide level, the APDCE census for the WAH was not conducted. This not only affected availability of aircraft but also resulted in a shortage of personnel during critical phases of the project. In addition, transmitters in almost half of the bear radio collars in the area failed prematurely, making it more difficult to locate bears in the vicinity of calving or migrating caribou. The end result of these complications was that even though data were collected and techniques evaluated, the study was not carried out as intensively as planned. Caribou composition counts and determination of cow:calf ratios were accomplished soon after the peak of calving. On the post-calving migration route, composition counts were made on an opportunistic basis since the field crew was observing bear/caribou interactions.

FINDINGS AND DISCUSSION

Although grizzlies are distributed throughout the study area, densities vary greatly from the Brooks Range north to the coastal plain (Reynolds 1978). The densities of bears in the mountains (elevation over 900 m) are approximately 1 grizzly/260 km^2; in the high foothills (600-900 m), 1/130 km^2; in the low (300-600 m) foothills and upland meadows, 1/50-130 km^2; and on the coastal plain (0-300 m), 1/780 km^2.

The traditional calving grounds of the WAH encompass an extensive area on the edge of the coastal plain and low foothills. However, most calving takes place only in a portion of this area during any one year.

So, depending on the specific location of the calving grounds in a particular year, caribou of the WAH may calve in areas of low grizzly bear density but could range into areas of moderate or even high bear density. In late June during the post-calving migration, caribou pass through the area of highest grizzly bear density in the study area; in early to mid-July during the post-calving shift they pass through areas of moderate and high bear density.

Movements of, or habitat use by, large aggregations of caribou in the study area can be broken down into four categories: spring migration to the calving grounds, calving, post-calving migration, and post-calving shift (Lent 1966, Skoog 1968). The direction and use of spring migration routes may vary depending on the areas used by caribou during winter. Although it may vary around a central area, the location of the traditional calving grounds probably does not change, and there is evidence that it has been used at least since the 1830's (Skoog 1968). The post-calving migration contains the largest aggregations of the WAH that form during any time of the year; this migration occurs along the same general route every year from the calving grounds in a southwesterly direction to the headwaters of the Kukpowruk and Kukpuk Rivers. The post-calving shift occurs from this area. During recent years most aggregations have turned east along the Brooks Range and northern foothills through the central and southern portions of the study area; however, in at least one year they traveled northeast along the Arctic Ocean coast (Davis and Valkenburg 1978).

The availability of caribou to grizzlies appears to be dependent more upon caribou calving in or moving through a bear's home range than on bears moving from home ranges to reach caribou concentrations. Of 34 bears for which home ranges were determined by radio telemetry, only two expanded their home ranges to reach caribou concentrations and these expansions were small. Generally, grizzlies did not move from their established seasonal ranges to reach calving or migrating caribou but instead moved to those portions of their ranges where caribou were available. As a result of this pattern, when caribou calve in areas of low grizzly density where few bears maintain home ranges, the amount of bear predation and scavenging is minimized. In years when caribou calve in the southern portions of the calving grounds, or when snow conditions result in caribou calving before they reach the calving grounds, the potential for contact with higher densities of grizzlies is increased and their vulnerability to predation is increased. After caribou leave the calving grounds in large aggregations they come in contact with higher densities of grizzly bears as they cross the foothills during post-calving migration. It is during this time that caribou of the WAH appear to be the most vulnerable to bear predation. In this early stage of the post-calving migration a few calves are still being born and cows which were debilitated by calving are still traveling with the aggregations. Lone cows or calves separated from and searching for each other probably have increased vulnerability to predation. And, although not confirmed by intensive study, it seems reasonable that the majority of cow-calf separations which occur after leaving the calving grounds would happen in the first week of post-calving migration.

During the post-calving shift they cross the study area in an easterly direction along the southern portion of the study area in the mountains and high foothills in early to mid-July. By this time, cows and calves are probably less vulnerable to predation; calves are better able to keep up with the migrating herd and cows have had a longer period to recover from any disabilities related to calving.

Although the interrelationships between movement and habitat use by WAH caribou, and movement and density of grizzly bears in the area have been established, data regarding the degree of use which grizzlies make of caribou as scavenged food or prey are incomplete and require further investigation. Some patterns of predation and scavenging behavior have emerged, but these should be viewed as tentative and contingent upon additional data collections.

Grizzlies fed on caribou in all portions of the study area from the calving grounds to the mountains; caribou were utilized both as carrion and prey. On the WAH calving grounds Lent (1964) observed grizzlies killing two calves and feeding on 10 others in the early 1960's. During the present study and related caribou studies (Reynolds 1978), grizzlies on the calving grounds were observed killing 1 calf in 1977, 7 calves in 1978, and none in 1979. These differences were due to several factors: in 1977 no effort was made to document grizzly bear/caribou interactions, but many caribou calved to the south prior to reaching the calving grounds; in 1978 calving aggregations used the low foothills where grizzly bear density was moderate; and in 1979 most calving caribou stayed north of the Utukok River where grizzly bear density was very low.

Along the post-calving migration route grizzlies were observed killing three calves in 1977; in 1978 no kills were observed but nine grizzlies were observed on carcasses. In 1979 observers watched grizzlies kill 3 calves and 1 adult female and feed on an additional 6 calves and 3 adults for which the causes of death were unknown. At least one of these calves was dead when found by bears, but the majority were probably killed by grizzlies.

During the post-calving shift and subsequent summer dispersal of WAH caribou in 1977 no bear/caribou interactions were observed; in 1978 grizzlies were observed feeding on the carcasses of seven yearling or adult caribou; in 1979 one bear was observed feeding on the carcass of an adult bull and a female grizzly and her offspring with fresh blood on their muzzles were seen among migrating caribou.

It appears that individual bears representing all sex and age classes of the population, prey on or scavenge caribou. During 1978 and 1979, 21 individuals were observed at caribou carcasses: 7 adult males, 2 subadult males, 4 solitary adult females, 4 females with offspring (each family group was counted as an individual), 2 subadult females, and 2 of unknown sex and age. Thus the proportion of bears of each sex and age class seen feeding on caribou carcasses was similar to their proportion in the population of this area (Reynolds 1978). However, even though it was established that bears of each sex and age class were active in predation or scavenging activities, the number of bears in each sex and age class and the proportion of the total population of bears regularly utilizing caribou were not determined. Some indications of these measures were observed in 1978: of 102 sightings of bears from 6 June to 3 July, the period when caribou are most available, a total of 9 observations (9%) were made of bears at caribou carcasses.

Some bears were more successful than others in killing caribou or locating and maintaining possession of carcasses. Most grizzlies were not seen on more than one carcass, but a female with yearling offspring killed four calves in 1977 and a different female with offspring was observed at two calf carcasses. Another female without offspring was seen at 3 carcasses in 1978 and an adult male was seen at 2 carcasses in 1978 and 7 in 1979. Although additional observations are needed, these data indicate that adult males are more successful in killing caribou or gaining possession of carcasses which other bears have killed or scavenged. This is a reasonable assumption since adult males are the largest and most aggressive members of bear populations (Hornocker 1962, Egbert and Stokes 1976). On the other hand, in 1979 at least one adult male which had actively sought caribou in 1978 was preoccupied with courtship and breeding activities when caribou were available during the post-calving migration and was not observed on any carcasses until the post-calving shift when caribou again passed through his home range.

The amount of time grizzlies spent at carcasses depended on the individual bear or family group and the size of the caribou. Some calves which were killed or found dead were consumed within 10 to 30 minutes. In 1977 a family group comprised of a female with three yearlings killed four calves within an hour on the calving grounds (J. Bryant, pers. comm.). Another female killed a calf shortly after she was darted from a helicopter, and before she was immobilized, carried the calf 0.8 km and ate almost one-fourth of it, all within a 10-minute period. Even though bears were capable of consuming calf carcasses rapidly, some bears laid down near the remains of calf carcasses (i.e. those portions which were not consumed--bone, hide, stomach, etc.) for an hour or more. On the other hand, bears stayed near the carcasses of yearling or adult caribou for much longer periods of time, often returning to a carcass after being absent from it for several days.

Grizzlies utilized several techniques to kill caribou. When caribou were in aggregations and resting or feeding, especially on the calving grounds, bears were observed "charging" these groups. The initial reaction of some groups was to run but then females and their calves which were separated from each other often milled around; during this confusion bears caught calves. Some bears used a variation of this method and simply chased moving bands of caribou. During unsuccessful charges bears would stop following these groups after running about 100 m, but some successful kills took place after chases of 0.5 to 0.8 km. The adult caribou which was observed killed was attacked in this manner; however, because caribou are usually able to easily outrun grizzlies, it is probable that this animal was debilitated by disease or injury. Grizzlies were also observed apparently locating calves by scent; whether these animals were injured, recently born, or different from other caribou in some way was not established.

Twelve bears, including a female with two yearlings and nine solitary bears, were attracted to a caribou crossing area west of the Kokolik River. River crossings probably increase the vulnerability of caribou to predation since cows and calves are often separated at river crossings; in addition, the physical stress caused by swimming the river may further weaken injured or infirm animals. During 1979 adult male no. 1082 was in this area between 15 and 21 June. On 16 June he traveled 13 km northwest to an area not used by migrating caribou but returned the next day. On 22 June he left the area and was with a breeding female the next day. During the time he was in the vicinity of the Kokolik River ford he was observed killing two calves and one adult and feeding on carcasses of at least three additional calves and one adult.

More data are needed before the extent of grizzly bear predation and scavenging behavior on WAH caribou can be estimated and the effects evaluated. The amount of calf mortality which occurs from all causes in the first 3 weeks after birth provides a measure of the availability of calves to the bear population but does not differentiate proportions attributable to bear predation. In 1979 the mortality rate of calves in the WAH during that period was estimated to be 35 percent or about 16,200 calves. If calves weigh an average of 5.9 kg (13 lb) at birth and gain about 450 g (1 lb) per day (Skoog 1968), a minimum total biomass of 95,000 kg (210,000 lb), including hide, bones and waste, was available to predators and/or scavengers in the area.

The effects of availability of caribou on the productive potential of the grizzly bear population in this area cannot be critically evaluated without additional data including rates of predation and scavenging for sexually mature females and survival rates for young-age bears. However, all measures of density and productivity in this study area where caribou are commonly utilized by grizzlies were higher than those same measures observed in the eastern Brooks Range in a study area of approximately the same size and at the same latitude (Reynolds 1978). The only other possible difference between the two areas was the "quality" of habitat; the western Brooks Range area contains more foothill habitat and the eastern Brooks Range area contains more mountainous habitat. However, the effects of caribou availability were felt to far outweigh differences in habitat since vegetation availability does not appear to be a limiting factor (J. Hechtel, pers. comm.).

RECOMMENDATIONS

Investigations of the interrelationships between grizzlies and WAH caribou should continue. Future investigations should be carried out in conjunction with intensive study of WAH caribou; the chronology of calf mortality and post-calving migration movements and whether migration route use varies from year to year should be established.

Bear predation study emphasis should be on determining: 1) rates of predation for sexually mature females, 2) the proportions of the bear population which are actively involved in predation, 3) the proportions of caribou killed by bears and scavenged by bears, and 4) extent of predation during caribou post-calving shift movements.

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